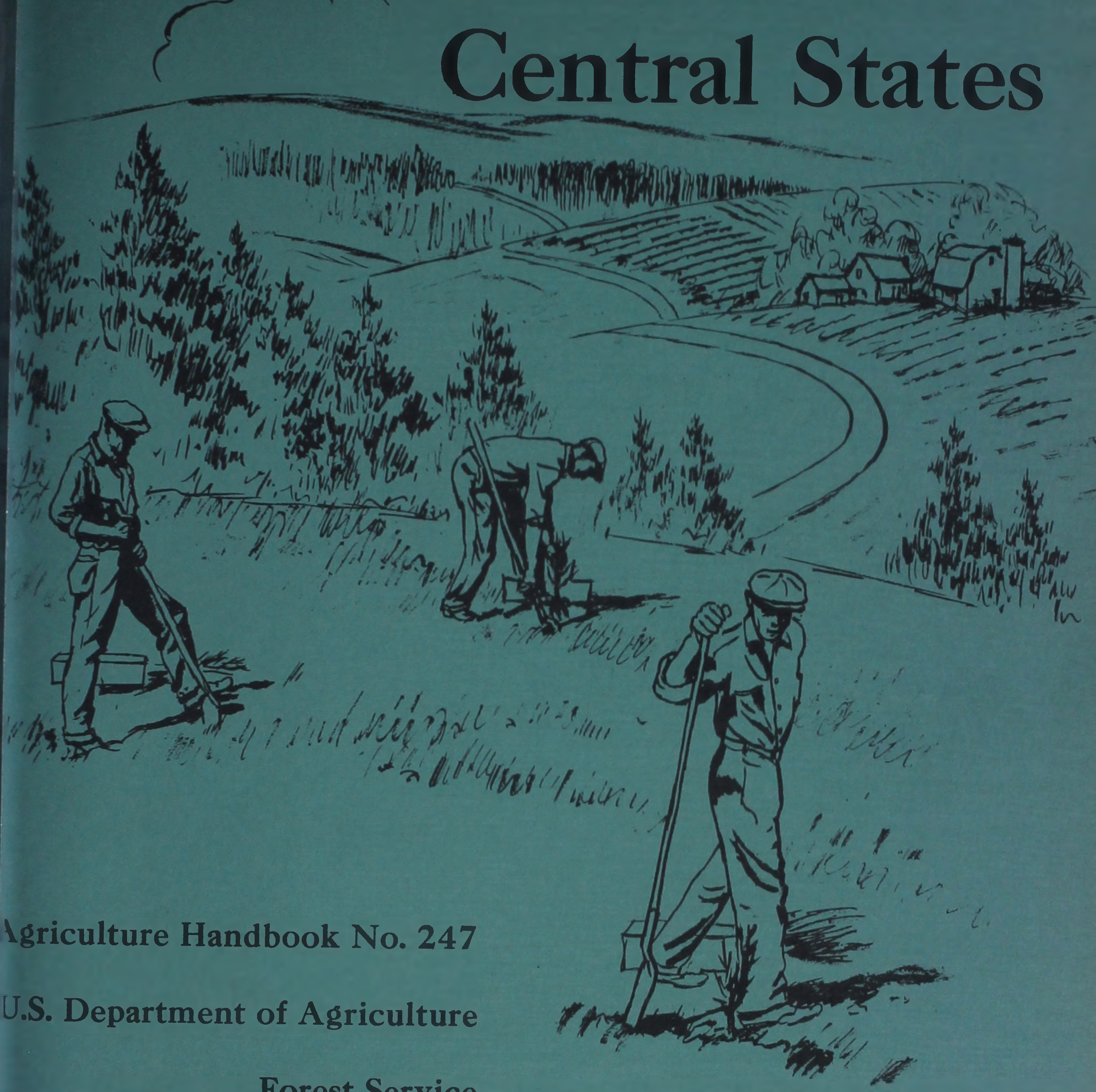
Forest Planting Practice in the Central States



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Forest Service

Forest Planting Practice in the Central States

By G. A. Limstrom, research forester,
U.S. Forest Service, Central States
Forest Experiment Station

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Introduction

For the past half century forest tree planting s been steadily increasing. Acreage planted per ar throughout the Nation doubled from 1953 1962. This is a significant milestone in the story of conservation in our Nation; it indicates rowing interest in the need for and value of tree nting. But the main job still lies ahead; the k of reclaiming idle land in the United States just begun (*156*).[1] In the Central States gion alone, for example, only about a million es have been planted, while the latest estimates the Department of Agriculture (*159*) indicate t more than 7 million acres, exclusive of erally owned land, are still in need of planting:

State	Land planted [1] (acres)	Plantable land [2] (acres)
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a	56, 919	254, 000
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Total	965, 888	7, 221, 000

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Although the ratio of successful plantations to failures has been fairly high, the acceleration in planting programs calls for a better understanding of the problems and techniques involved. Recent technological developments have outmoded practices that were standard less than two decades ago. And today, more than ever before, landowners with little experience in tree planting are seeking advice on the subject.

This handbook presents the latest available information on tree planting in the central hardwood region—where to plant, what to plant, and how to plant. It was prepared especially for the men to whom landowners usually go when seeking advice on tree planting—the extension forester, farm forester, forest ranger, consulting forester, county agricultural agent, and soil conservationist. For the Central States Region, it replaces Farmers' Bulletins 1123, 1453, and 1994—"Growing and Planting Hardwood Seedlings on the Farm," "Growing and Planting Conifers on the Farm," and "Tree Planting in the Central, Piedmont, and Southern Appalachian Regions."

The material presented here deals primarily with the planting of trees for timber production, erosion control, and watershed protection. Much of it applies equally well to planting windbreaks, shelterbelts, and Christmas trees, but the unique features of these specialty plantings are not treated.[2]

Where Should Trees Be Planted?

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Having once established his motives for planting trees and his desire to do so, the first problem confronting a prospective tree planter is the decision of where to plant. He will need to consider his potential planting sites individually. Whether a given tract of land should be planted to trees depends upon the answers to three questions: Will trees grow there? Will it pay to grow them there? And, is it necessary to plant them there?

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About 100,000 acres of federally owned land in the Central States are in need of planting.

The phenomenal increase in planting during the past decade is traced mainly to a growing awareness among individual landowners of the need for and desirability of establishing forest plantations. Motives for planting are varied, but the principal ones are to restore idle land to productivity, to control erosion, to establish windbreaks, and to develop areas for recreation and wildlife habitats.

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The answer to the first question has to do with the productivity of the land, and productivity is such an important subject that it will be considered by itself in the following section.

The second question has to do with economics. Whether or not it will pay to plant trees on a given area depends upon the purpose of the proposed plantation. If the purpose is to stabilize the soil, control erosion (fig. 1), or protect a watershed, the plantation will pay if the stated purpose is accomplished. On the other hand, if the purpose is to grow a merchantable crop, whether it be Christmas trees, pulpwood, fence posts, or sawtimber, the question can be answered in terms of dollars and cents; i.e. whether more money can be made by growing trees or by growing some other crop on the land.

Very few plantations in the Central States are old enough to indicate prospective sawtimber yields. However, there are many immature plantations, from which probable yields of posts and cordwood for a number of species, ages, and localities can be estimated (fig. 2, table 1).

In many instances the decision to plant is easy. If a piece of land is obviously unsuited for farm crops because of erosion, location, topography, or geology, then planting trees is one of seve alternatives to consider.

The third question, is it necessary to plant, c be answered by examining the area for "pla ability," i.e., whether it has less than a desira number of trees for fair or good stocking. If area has a sufficient number of well-distribut desirable trees per acre, no planting is necessa If stocking is poor, however, and it is not lik that enough natural restocking will occur 5 years, the area is "plantable."

To determine plantability on areas cover partly with desirable and undesirable tre sample tallies should be taken to determine sto ing by species. Because distribution of the sirable trees is also important, only one desira tree on each milacre (6.6 feet square) should counted. Stocking standards to determine pla ability are shown on page 3.

In the Central States there are three bro classes of plantable land, each different from t others in species suitability, productivity, a appropriate techniques for planting: (1) op poorly stocked land, (2) cutover or partly stock forest land, and (3) strip-mined land. The th class, strip-mined land represents the extre

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Figure 1.—Tree planting is an excellent way to restore badly gullied land to greater productivity and to stop further erosion

...ze class [1] (Diameter at breast height)	Land is "plantable" if it has less than the following trees of desirable species per acre—	
	Fair stocking (number)	Good stocking (number)
...eedlings:		
Less than 1 inch	400	600
...aplings:		
1 to 4 inches, small	200	300
4 to 6 inches, large	100	200
...oles:		
6 to 8 inches, small	40	120
8 to 10 inches, large	30	75
...aw logs:		
10+ inches	10	40

[1] For a combination of two or more size-classes reduce ...ocking to seedlings by use of following equivalents: ...e saw-log tree is equivalent to 15 seedlings; 1 large ...le=8 seedlings; 1 small pole=5 seedlings; 1 large sap...g=3 seedlings; and 1 small sapling=2 seedlings. ...or example an acre with 3 saw logs, 10 large poles, 5 ...all poles, 20 small saplings, and 100 seedlings would ... equivalent to 290 seedlings and, therefore, classified ... plantable.

disturbed sites. Here the soils has undergone ...mplete upheaval, often to a depth of many feet, so that the resulting surface "soil" bears little resemblance to the original. These artificially created conditions are so unique that a special bulletin has been published dealing with planting on such land (*75*). Hence we will be concerned here only with the first two classes.

Open, Poorly Stocked Land.—Open, poorly stocked land includes prairie land that never was in forest, and land that was originally forested but at some time in the past was cleared and used for some other purpose, usually farming. Less than half of its surface is covered by a canopy of tree crowns, and there are less than the prescribed number of desirable trees per acre (see tabulation above). This includes some land now being farmed but which is more suitable for growing trees (fig. 3, *A*) and a great deal of land once used for agriculture but later abandoned (fig. 3, *B*). The old fields of the Central States are typical of poorly stocked forest land that should be planted to trees. Most tree planting will be done on this kind of land.

TABLE 1.—*Sample yields of immature plantations in the Central States*

Species	Location	Thinnings		Growth and yield [1]			
		Age	Volume removed per acre	Age	D.b.h., average	Height average	Volume per acre [2]
		Years		*Years*	*Inches*	*Feet*	
...rtleaf Pine	Southern Illinois	17	¼ stand	20	5. 9	33	17 cords
	Southern Ohio	------	Not thinned	23	7. 0	42	17 cords
	Southern Indiana	14 21	3.2 cords 8.6 cords	21	7. 1	40	20 cords
	Missouri Ozarks	16 20	5.5 cords 660 posts	20	7. 5	40	840 posts
...olly pine	Southern Illinois	13	318 8-ft. mine props and 183 7-ft. posts	17	7. 4	44	15 cords
...ern white pine	Eastern Iowa	------	Not thinned	51	10. 9	70	33,467 bd. ft.
	Northern Illinois	34 39	2,742 bd. ft. 1,746 bd. ft.	39	8. 9	53	16,123 bd. ft.
...ern redcedar	Northern Arkansas	------	No thinning records	44	6. 0	40	5,866 posts
...pine	Southeastern Ohio	------	Not thinned	41	8. 5	52	10,324 bd. ft.
...onwood	Missouri:						
	Not thinned	------	----------	14	8. 9	82	20.97 cords
	Thinned	8	3 cords	14	10. 0	82	20.29 cords
...tgum	Southeastern Ohio	------	Not thinned	40	8. 3	55	14 cords
...w-poplar	Eastern Ohio	------	Not thinned	18	5. 0	40	19 cords
... walnut	Central Missouri	------	Not thinned	14	5. 0	35	No record

[1] The average diameters at breast height (d.b.h.) and average heights are for trees making up the overstory of the ...ation; not included are the few overtopped and suppressed trees found in most plantations.
[2] Does not include volume removed in thinnings. Board-foot volumes from tables based on International ¼-inch ...le.

Figure 2.—Posts and poles removed in thinning 20-year-old plantation of shortleaf pine in Missouri. This thinning yielde equivalent of 660 posts out of a total estimated stand of 1,500 fence posts per acre. The stand was also thinned at 16 yielding 5.5 cords of pulpwood.

The landowner's decision to plant or not to plant such land should rest mainly on the possibility of the land restocking naturally to a forest (*118*) of desirable trees within a reasonable period of time, say 5 years. In old fields examined in central Missouri by Drew (*39*) 30 to 35 years after abandonment, sassafras and persimmon were still prominent components of the cover, "suggesting a long interval of time prerequisite for reestablishment of such forest conditions" as existed before the land had been cleared for agriculture.

When debating the question of whether land will restock naturally, several points should be considered. Size of the potential planting site is of primary concern. A large parcel of land, most of which is a long way from natural seed sources, will take much longer to revert to forest than a smaller one. The rate at which this succession proceeds depends on a number of factors. In a study of 60 randomly selected old fields adjacent to forested areas in southeastern Ohio, the principal factor influencing the rate of succession was the distance from seed sources as measured by the size of the field (*91*): smaller the field the faster it reverted to fo Then too, in order to depend on the nat development of a good forest, there must be trees of desirable species in adequate num nearby. And finally, the site must be in condition that the desirable trees can bec established, survive, and grow without u competition from associated herbaceous brushy vegetation.

According to the Illinois Technical Fore Association (*63*), "The best sites usually dev blackberry briars or hardwood brush within 4 years. Medium to poor sites gradually from annual weeds and grasses through bro sedge or other perennial grasses and eventu into briars and brush. The poorer the site, longer this ecological succession requires. Hea eroded sites in southern Illinois with all the A part of the B soil horizon removed may req 10 years or more to come into broomsedge another 10 to 20 years to form a moderately cover of brush and briars. Such areas often not, unaided, develop a full stand of desir

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gure 3.—*A*, Some land used for agriculture, such as this worn-out gullied cornfield should be planted to trees. *B*, Most of the tree planting will be done on open, poorly stocked forest land such as this typical old field in Ohio.

ees for a hundred years or longer." Because of e loss of productivity through erosion and anges in the land surface, some kinds of trees ited to former conditions of the land are no nger suitable.

Some prairie and grassland may be best suited r growing trees even though it has never supted a forest cover (*80*). Dry, exposed bluffs ong the Missouri River in Iowa and many gularly flooded bottom lands are examples. xcept for shelterbelts and landscaping, most of e trees planted on prairie and grassland will be r posts, poles, Christmas trees, and fuel; it is oubtful whether high-quality sawtimber could produced on these sites, particularly on the avy, fine-textured prairie soils. For example, e growth of white pine, Scotch pine, European rch, and Norway spruce on some prairie soils in inois was normal during the first 30 years after anting and then sharply declined and stagnated 9). The growth pattern of hardwoods on airie soils, though not as striking as that of nifers, shows similar trends (*168*).

Cutover or Partly Stocked Land.—"Cutover nd," as used here, is land that has been logged t not cleared for any other use. "Partly stocked land" is land that has been open in the past but now is more than half covered with trees. This land may either be prairie land or old fields that is being invaded by trees but is only partially stocked with desirable species. To be classed as "partly stocked" and "plantable" each acre should (1) have more than half its surface covered by a canopy of tree crowns (fig. 4, *A*), (2) have less than the prescribed number of trees of desirable species (see p. 3), and (3) show no prospects of becoming stocked naturally to the minimum number of trees of desirable species within 5 years (fig. 4, *B*).

Much cutover land does not, of course, need planting. Most of the planting on cutover land will be on areas so severely burned or logged that there is little likelihood of natural restocking to desired species within a reasonable period of time.

Site conditions for planting on partly stocked old fields are more like those of cutover land than of open, poorly stocked old fields. Some soil properties have been improved by the presence of the trees (*32*, *9*); leaf litter covers part of the ground and some duff and humus—typical of forest soils—is being formed. The microclimate resulting from tree cover is, moreover, much different than on open, poorly stocked land. For

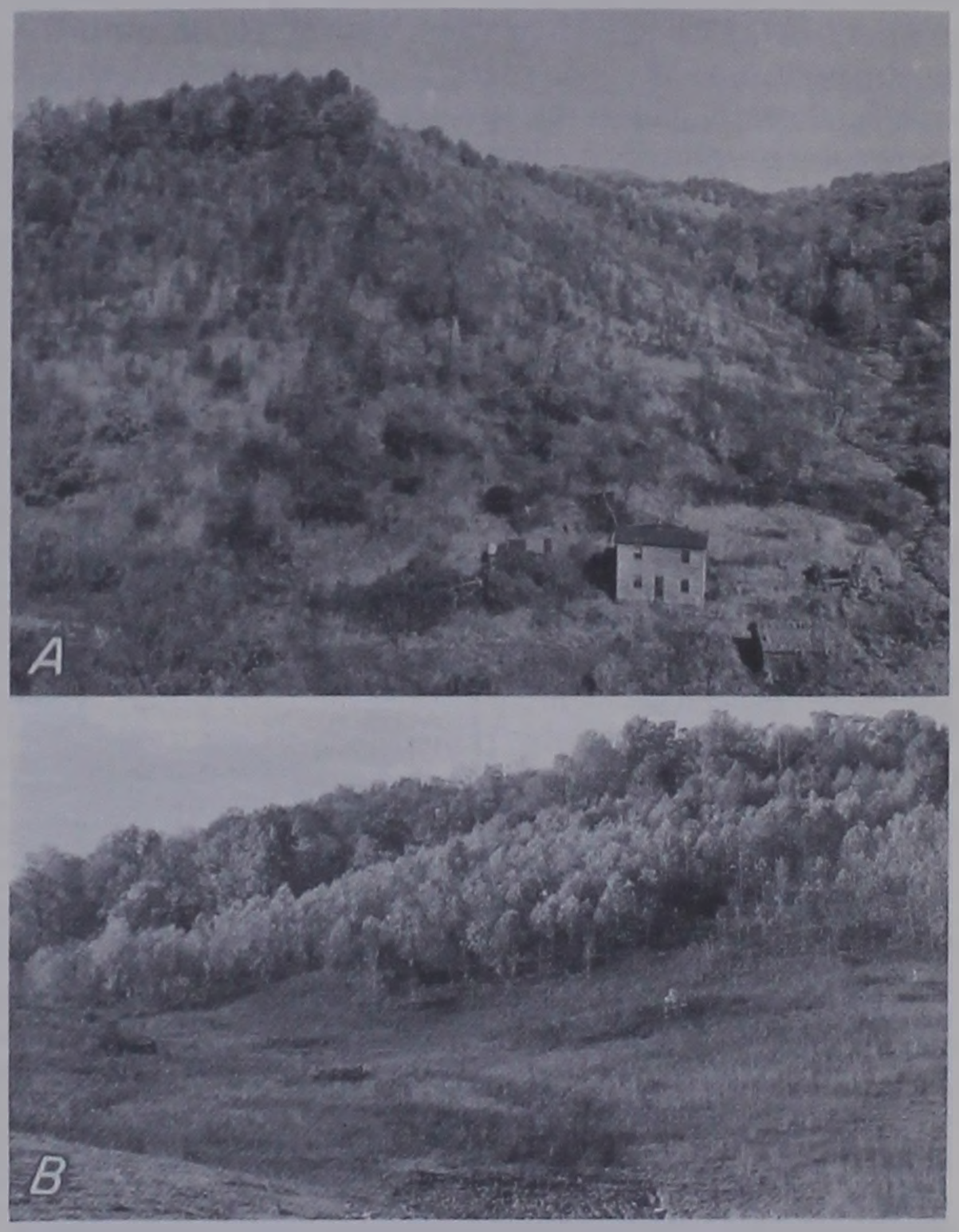

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Figure 4.—*A*, Natural succession has proceeded so far on this old field that in a few years it can no longer be classified as poorly stocked. *B*, Only the edge of this old field has become well stocked with yellow-poplar. The field has not been cultivated for more than 30 years, and not grazed for 17 years.

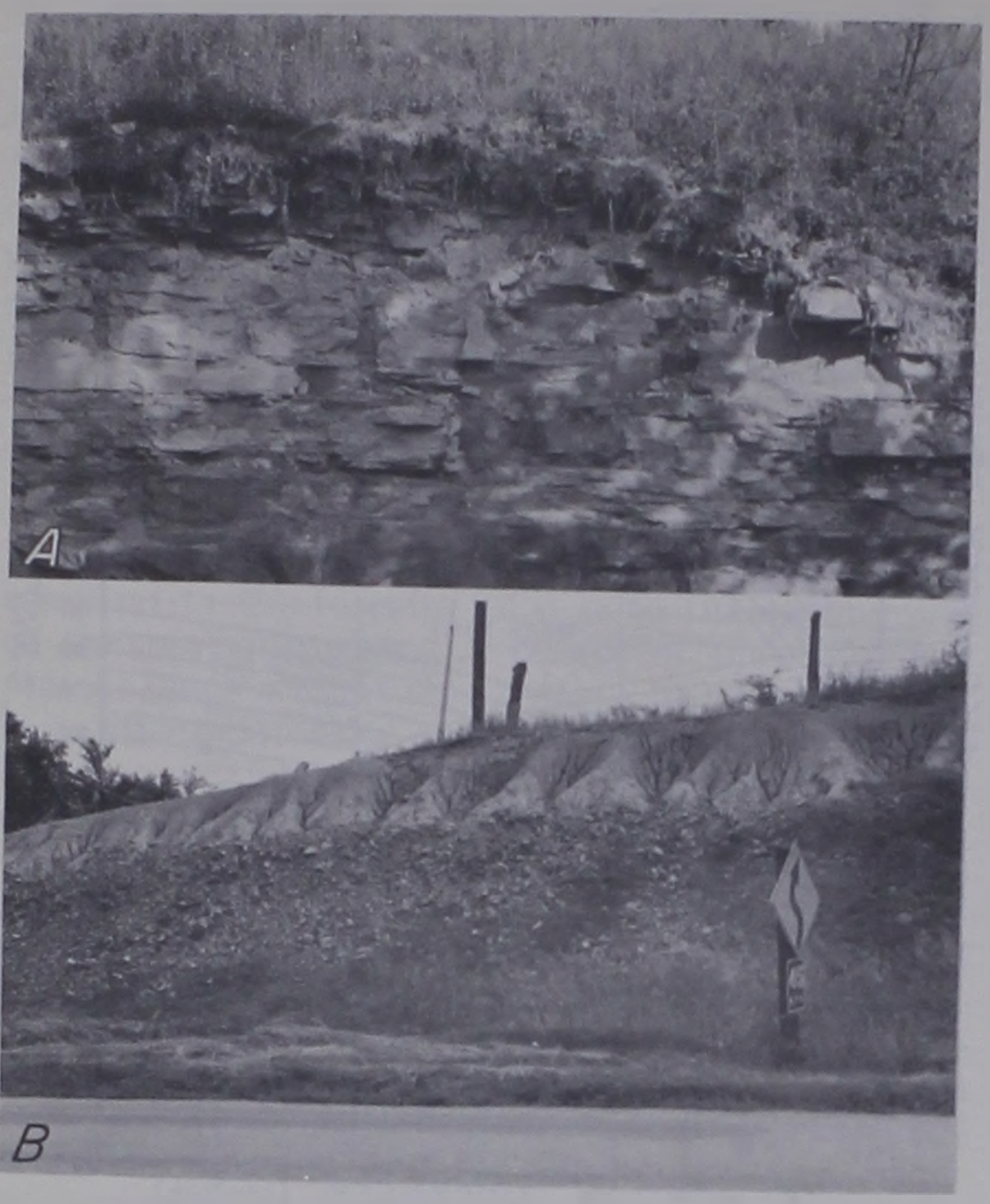

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Figure 7.—*A*, Solid bedrock near land surfaces restricts effective rooting depth of trees. Such sites as a rule are droughty and not as productive as those with deeper soils. *B*, Shallow loessial soil material with a highly permeable stony substratum. During periods of deficient rainfall these soils are droughty.

Drainage.—Drainage (i.e. water movement over and through the soil) greatly affects the balance of moisture and air in the soil. It is related chiefly to (1) topography; (2) soil texture, structure, thickness, and character; (3) the amount of litter and duff on the soil surface; (4) permeability of the soil; (5) depth to, thickness, and permeability of hardpans, substrata, and bedrock; and (6) the depth to the water table. Many other factors are also involved, but for planting-site evaluations they need not be considered.

"Variations in soil drainage can be related by inference to differences in soil color and patterns of soil color" (*153*). Gleying, a term used to describe the process caused by waterlogging and lack of oxygen, gives some soils a neutral gray color. Soils mottled with yellows and grays, caused by intermittent waterlogging, are usually poorly drained. Soil color, however, also varies according to the vegetation under which the soil has formed. In the Central States, soils formed under forest vegetation are characteristically brown, gray brown, or gray, while those developed under prairie or grassland vegetation are dark brown or black.

The following general soil-drainage classes, based on soil color and topography and reflecting rates of runoff, soil permeability, and internal soil drainage, were developed by the Soil Conservation Service (*153*) and should aid in classifying soil tree planting:

"0. *Very poorly drained.*—Water is rem from the soil so slowly that the water tabl mains at or on the surface the greater part of time. Soils of this drainage class usually occ level or depressed sites and are frequently pon Very poorly drained soils commonly have d gray or black surface layers and are light g with or without mottlings, in the deeper part the profile. In the grassland regions, very po drained soils commonly have mucky surfaces distinct evidences of gleying.

"1. *Poorly drained.*—Water is removed slowly that the soil remains wet for a large pa the time. The water table is commonly a near the surface during a considerable part of year. Poorly drained conditions are due to a water table, to a slowly permeable layer wi the profile, to seepage, or to some combinatio these conditions. In the podzolic soil reg poorly drained soils may be light gray from surface downward, with or without mottli Among the dark-colored soils of the grassla poorly drained soils commonly have slig thickened dark-colored surface layers.

"2. *Imperfectly or somewhat poorly drained.*—Water is removed from the soil slowly enough keep it wet for significant periods but not al the time. Imperfectly drained soils commo have a slowly permeable layer within the pro a high water table, additions through seepage a combination of these conditions. Among podzolic soils, somewhat poorly drained soils uniformly grayish, brownish, or yellowish in upper A horizon and commonly have mottli below 6 to 16 inches in the lower A and in th and C horizons. Among the dark-colored soils the grasslands, somewhat poorly drained s have thick, dark A horizons, high in orga matter, and faint evidences of gleying immediat beneath the A horizon.

"3. *Moderately well drained.*—Water is remov from the soil somewhat slowly, so that the pro is wet for a small but significant part of the ti Moderately well-drained soils commonly have slowly permeable layer within or immediat beneath the solum, a relatively high water tab additions of water through seepage, or some co bination of these conditions. Among podzo soils, moderately well-drained soils have unifo colors in the A and upper B horizons, with mottli in the lower B and in the C horizons. Among t dark-colored soils of the grasslands, profiles ha thick, dark A horizons and yellowish or grayi faintly mottled B horizons.

"4. *Well drained.*—Water is removed from t soil readily but not rapidly. Well-drained soils a commonly intermediate in texture, although so of other textural classes may also be well draine Among the podzolic soils, well-drained soils a free of mottlings (except for fossil gley), and ho zons may be brownish, yellowish, grayish, reddish. They may be mottled deep in the

horizon or below depths of several feet. Among the dark-colored soils of the grasslands, well-drained soils have thick, dark A horizons; reddish, brownish, or yellowish B horizons; and C horizons that may or may not be mottled. Well-drained soils commonly retain optimum amounts of moisture for plant growth after rains or additions of irrigation water.

"5. *Somewhat excessively drained.*—Water is removed from the soil rapidly. Many of the somewhat excessively drained soils have little horizon differentiation and are sandy and very porous. Among podzolic soils, somewhat excessively drained types are free of mottling throughout the profile and are brown, yellow, gray, or red. Among the dark-colored soils of the grasslands, many profiles have relatively thin A horizons; brownish, yellowish, grayish, or reddish thin B horizons; and no mottlings within the solum. Only a narrow range of crops can be grown on these soils, and the yields are usually low without irrigation.

"6. *Excessively drained.*—Water is removed from the soil very rapidly. Excessively drained soils are commonly lithosols or lithosolic (with little or no soil profile development), and may be steep, very porous, or both. Shallow soils on slopes may be excessively drained. Among podzolic soils, excessively drained types are commonly brownish, yellowish, grayish, or reddish in color and free of mottlings throughout the profile. Among the dark-colored soils of the grasslands, profiles commonly have thin A horizons (except for sand types that may have thick ones)."

Pines, as a group, are unsuitable for planting in poorly drained soils. Among the conifers, baldcypress is perhaps the most tolerant of wet conditions. Hardwoods differ in their tolerance of periodic flooding (*179*); there are apparently few if any adverse effects of flooding on hardwoods during the dormant season. Mortality caused by flooding during the growing season, however, is high for some species even after they have become well established. In a study of the effects of various periods of summer inundation on the mortality of pole-sized trees or larger, Williston (*172*) found that all yellow-poplars flooded for 30 days died, and those flooded for only 10 days were damaged. Sixty percent of the red oak and 62 percent of the white oak flooded for 21 days died. Eighty-six percent of the sweetgum, and 73 percent of the red maple survived after being inundated for at least 21 days.

Aspect and Topography.—The direct and indirect effects of position on the slope and of aspect on tree and soil development are difficult to separate. The direct effects are differences in microclimate brought about by differences in slope steepness or aspect. Temperatures, evaporation rates, and sunlight intensity are lower on northerly aspects than on southerly aspects. Winds are generally stronger on upper slopes than on lower slopes; and in areas of sharp relief there may be marked differences in precipitation and wind velocities among all aspects.

Among the indirect effects sometimes associated with differences in slope steepness or aspect are differences in soil thickness, texture, and structure; available soil moisture; acidity; permeability, and drainage; they account for the differences in site quality between uplands and lowlands, steep and gently sloping land, coves and ridgetops, and among terraces, first bottoms, and second bottoms.

Gaiser and Merz (*50*) found that aspect, topographic position, and slope had little effect on the growth of red and white pines planted on old fields in southeastern Ohio and southern Indiana. Similar results were reported by Allen (*2*) for shortleaf, loblolly, Virginia, and white pines; yellow-poplar; and black locust plantations in the Tennessee Valley. But, because these plantations were chiefly on old fields, most of them were not located on extremely steep slopes.

Gaiser (*49*) and Doolittle (*38*) have reported definite relations of site index of trees in natural stands to slope position and aspect when all degrees of slope are considered. Steep slopes are more common on cutover land than on old fields, and on these sites, aspect and steepness are more important to consider in selecting species for planting than on old fields in the southern parts of the region.

Although differences in site quality among aspects and slope positions no doubt exists, in most localities there is generally not enough difference in tree development on such sites to affect choice of species. However, for certain species and sites, such as conifers in the prairie regions and yellow-poplar (*132*) on cutover land in the southeastern part of the region, slope and aspect need more careful consideration. The differences in site quality between uplands and bottom lands are generally so obvious that they often form the basis for major classification of sites for a locality or region.

Parent Material.—The parent material (rocks and minerals from which soils are formed) for most of the upland soils in the southern half of the Central States is underlying, consolidated rock (fig. 8). Parent materials are predominantly sandstone, limestone, shale, dolomite, and clay. Extreme variations occur in texture, permeability, topsoil depth, and other soil properties. Original forest cover was chiefly hardwoods, but pines were dominant on some of the dry sites. Because of these variations in soil characteristics and topography, the species for each site should be chosen carefully.

Much of the Central States is covered by materials left by the glaciers. Glacial drift develops into various kinds of soils. Many contain stones of various sizes but are, as a whole, productive and suitable for many tree species. In Missouri, Iowa, and Illinois the original cover on glacial soils was chiefly prairie vegetation, while in other parts of the Central States the original cover was hardwood forest.

Lake plains, formerly covered by post-glacial lakes, are rather extensive in northern Illinois,

Figure 8.—General location of principal parent materials of soils in the Central States. From Atlas of American Agriculture (151

Indiana, and Ohio. The soils in these old lake beds range in texture from coarse gravel or sand to "tight" impermeable clays. The potholes and depressions so common in these areas were no doubt the deepest parts of these extinct lakes.

In northern Missouri (*71*) and most of Iowa and Illinois, the glacial drift has been covered by wind-blown material—loess—of various thicknesses ranging up to more than 50 feet in some localities. Loessial soils are predominantly silt loams and, with alluvium, are among the most productive soils in the region. The original cover was mainly grass; forests consist mainly of hardwoods and redcedar.

Most of the soils in broad valleys and bottom lands were formed by the action of water melting from the glaciers and later overflowing from rivers and streams. These soils are variable in texture and permeability, and the original vegetation was forest in some localities and grass in others. The original forest cover was predominantly hardwoods—cottonwood, willows, gums, sycamore, boxelders, and many other species. Ground cover—grasses, shrubs, and weeds—is invariably so luxuriant on alluvial soils that it is difficult and expensive to establish plantations on them.

Colluvial soils—those developed on lower slopes and adjacent bottom lands from material that has fallen from upper slopes—are common in the hilly

ections of the region. They are generally more roductive than soils on slopes above them, be- use they are deeper and more permeable.

The mineral character of the soil, through its influence on texture, nutrient supply, and soil cidity, greatly influences the productivity of the te and the species that will grow there. Soils erived mainly from sandstone, quartzite, and ndy shales have a relatively low nutrient con- nt; phosphorous and potash especially are cking (*169*). Limestone, dolomite, and some ales have a high calcium content but also are metimes deficient in potassium and phosphorous.

Tree growth is affected by soil acidity. Soils erived from rocks such as limestone and dolomite e calcareous or acid, depending upon how much aching has taken place. Other soils, unless they ve been limed, are acid. Some soils derived om carbonaceous or bituminous shale may be ghly acid. Although there is a wide range in idity within which most species are adaptable, me hardwoods, such as yellow-poplar and cotton- ood, grow best on soils that are slightly acid to lcareous.

Pines, as a group, are better suited to acid soils an are many hardwoods (*45*). Redcedar, Euro- an larch, and Austrian pine, on the other hand, well on calcareous soils. Although many pines will grow when planted on calcareous soils, germination of seed is invariably poor (*24*), making direct seeding on this kind of soil impractical. Moreover, it would be difficult to regenerate the pines naturally for succeeding rotations.

Past and Current Use of Land.—Once land has been cleared and used for pasture or for cultivated crops, the former composition of the forest is not a good guide for selecting species to plant. Tree cutting, burning, grazing, and cultivation can make profound changes in the productivity of the land (*23*) (fig. 9). Some of these changes, caused by erosion and compaction, are obvious and can be readily appraised; others, such as changes in nutrient availability, soil structure, and the character and extent of soil micro-organisms, are not yet fully understood. Nevertheless the performance of numerous species planted on many of these sites has shown conclusively that some species, especially hardwoods, adapted to the land before it was cleared for agriculture are not suitable for replanting on the area (*4*, *54*, *55*, *97*). However, hardwoods can be planted on many old fields that have restocked naturally (fig. 10). On such sites, soil structure has improved and beneficial soil micro-organisms apparently are more abundant (fig. 11) (*30*).

F-364307

re 9.—This land in southern Illinois at one time no doubt supported a good stand of hardwoods. Today, after severe erosion and gullying caused by plowing up and down slopes, it is more suitable for the planting of conifers.

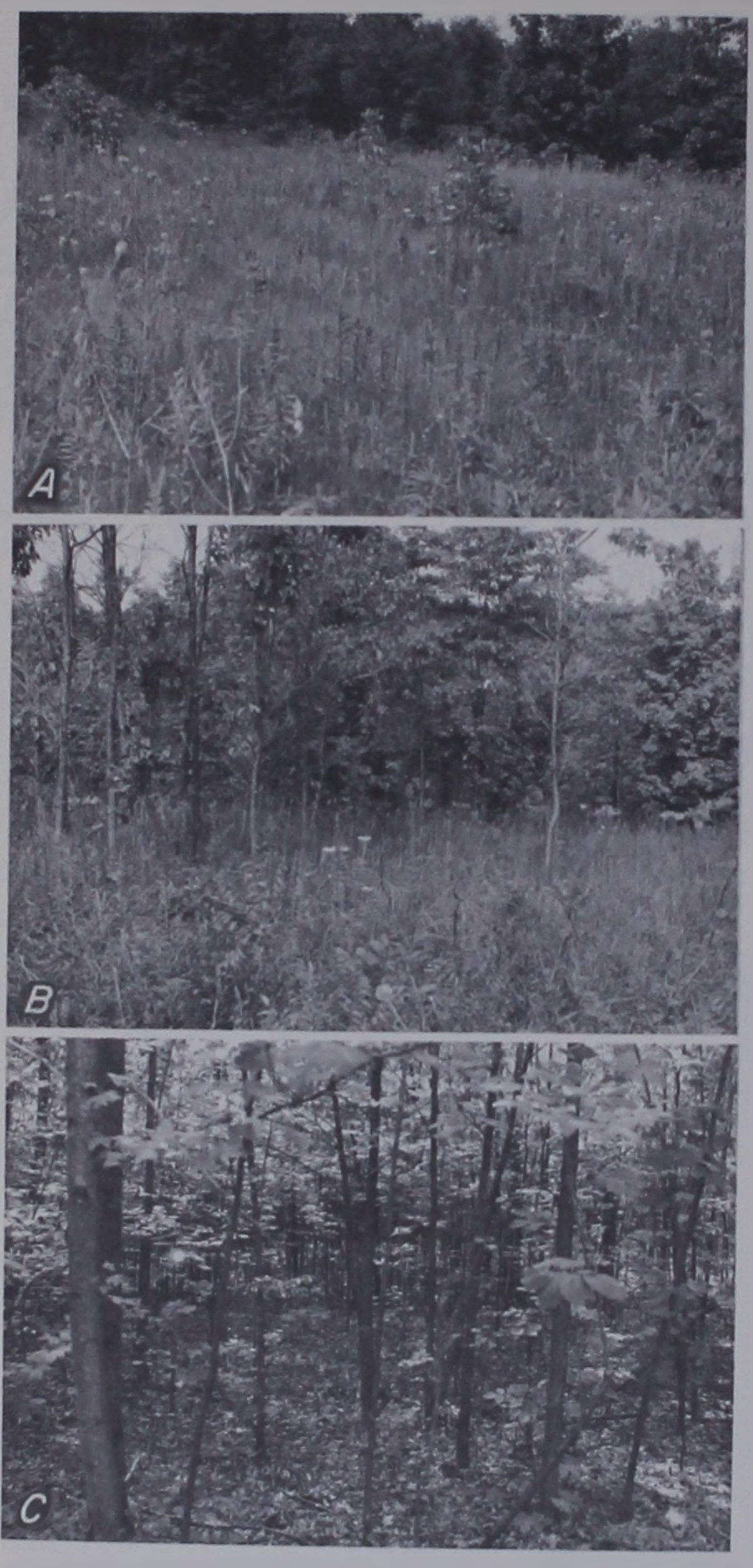

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Figure 10.—Stages in succession of an old field: *A*, First-stage vegetation composed mainly of grasses and weeds. *B*, Second stage, although still classed as poorly stocked, seedlings and and a few saplings have appeared; ground cover is still predominantly grass and weed. *C*, Fully stocked with trees; grass cover absent.

Land, such as the prairies, that never supported tree growth presents different planting problems. Trees of some species planted on these sites do not attain the size or form they do in their native habitat (*98*). Prairie soils are often lacking in soil micro-organisms, such as mycorrhiza, that are needed for good tree growth. The selection of species for these sites therefore requires special consideration.

Forest land recently cutover, but not otherw altered by burning, clearing, grazing, or plowi usually provides good growing conditions planted trees, providing care is taken that th are not overtopped by ground cover or the tr remaining in the stand. Because logging in past may have removed the best trees in th stands, the composition of the stand before recent cutting may not reveal the true potent of the site. Many of our defective hardwo stands formerly grew species of higher commerc value.

Because of these effects of past uses and curre cover on the survival and development of plan tions, it is considered necessary to recomme different species for planting on open, nonstock land than on cutover or poorly stocked land.

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Figure 11.—Twelve-week-old yellow-poplar seedlings prop gated from seed in potted soil sample cores: *A*, The benefic effects of micro-organisms are apparent in both old field a forest soils; *B*, seedlings in the soil from a fully stocked field are as well developed as those in the forest soil. See ling development in the half-stocked old field soil however, no better than that of the seedlings grown in s from the nonstocked part of the same old field.

What Kinds of Trees Should Be Planted?

Selecting the species to be planted is perhaps the most critical decision to be made in advance of planting. Species chosen must be adapted to the site, the climate, and the purpose of the plantation.

SELECT SPECIES ADAPTED TO THE PLANTING SITE

This rule can hardly be overemphasized. Most plantation failures result from not choosing the right species for each site (*36*). In fact if conditions differ from one part of a planting site to another, different species are often necessary.

The kind of trees that grew on the site before it was cleared is not always a good guide to what should be planted now. This is especially true on land that has been cleared for a number of years. So choose a species that is adapted to the site as it is today—not as it was 20 years or more ago.

Failure to foresee the adverse effects of poor drainage on the survival and growth of many species of hardwoods and conifers has also caused poor results. The adverse effects of dense ground and brush cover on the survival and growth of many conifers and the significance of erosion (*1*) and topsoil thickness have sometimes been ignored.

SELECT SPECIES AND SOURCES ADAPTED TO THE LOCALITY

On the other hand, be sure to choose a species that has been proved to be adapted to the local climate. Seedlings planted should be of a species native to the area or one that has grown successfully in nearby plantations. It is best, in fact, if the seed used to produce the planting stock is from local trees. This is because many species have developed local races or ecotypes that are specially adapted to the specific combination of day length, temperature, and precipitation that prevails in a particular vicinity.

Selection of sources adapted to local temperature extremes, especially cold, is important. Frost-caused dieback in a 3-year-old yellow-poplar plantation in Ohio was more than twice as extensive on trees of southern origin than on those of local or more northern origin (*47*). Similarly, of six different geographic sources of loblolly pine planted in southern Illinois, there was much less frost-kill in trees from the northern sources (Maryland, Virginia, and Arkansas) than in those from the three southern sources (North Carolina, South Carolina, and Mississippi) (*174*). And Meuli and Shirley (*92*) reported more drought resistance of green ash seedlings from the northwestern parts of the prairie-plains region than from the southern and southeastern parts.

Although loblolly pine is not native to the Central States, so many successful plantings of this species have been established north of its natural range that it has been listed as suitable for many sites in the southern parts of the region (*5*). It is susceptible to severe glaze damage and winterkill, but if owners accept this risk there is a good chance of higher yields than from other species. Loblolly pine planting stock should be obtained from seed sources located at the northernmost parts of its natural range.

New varieties and hybrids are constantly being discovered or developed; some of these are superior to planting stock currently used (*69*). For example, two natural hybrid poplars, one exhibiting rapid growth, another possessing a wavy grain desirable for veneer stock, have recently been discovered in Iowa (*77*). Hybrids of pitch-loblolly and shortleaf-loblolly pines also appear promising (*40*). A review of recent literature or consultations with workers at forest and agricultural experiment stations should be made before choosing new hybrids and varieties for large-scale plantings.

SELECT SPECIES AND SOURCES SUITABLE FOR PRODUCT DESIRED

Most forest plantations in the Central States are established to produce some kind of commercial product. Ranging from Christmas trees to sawtimber, the products desired of course determine the selection of species to be planted.

Species differ greatly in their suitability for specific uses. Criteria for considering the relative merits of each species for various uses are too numerous to discuss in this handbook. A number of publications on this subject are available (*143, 85, 155*). Lists of species commonly planted in the Central States, together with the products for which they are suitable, are given here, however (tables 2 and 3). The lists also give some of the most important factors to consider in choosing species for planting. These include an estimate of the number of years required to grow the product desired, the potential quality, and critical production factors that often affect the success or failure of a plantation.

In recent years selection of trees for planting has become more and more refined. Today specific strains and sources of certain species may be selected not only for their adaptability to given sites, as previously discussed, but also for their superior product characteristics.

Some trees of the same species but from different sources may differ widely in rate of growth, resistance to disease and insects, stem and crown form, color of foliage, branchiness, and wood quality. For example the marked differences in stem form, foliage color, and growth rate of Scotch

689–570 O—63——3

pine from various parts of Europe are well known. Moreover, Minckler and Ryker (*100*) have reported striking differences in foliage color, crown form, and growth of redcedar from eig geographic sources in experimental plantings southern Illinois.

TABLE 2.—*Potential products from coniferous plantations in the Central States* [1]

Species and chief uses	Years to produce	Quality	Critical production factors [2]
Larch, European:			
Logs (lumber, poles, farm timber)	50–80	Fair	
Pine, Austrian:			
Christmas trees	8–12	do	Form, color.
Posts	15–25	do	
Logs (lumber, farm timber)	70–90	do	Early stagnation limits yield. Need cast fungus.
Pine, jack:			
Christmas trees	5–8	Poor to fair	Form, color important.
Pulpwood and posts	20–30	Fair to good	
Pine, loblolly:			
Pulpwood and posts	15–30	Good	Glaze, frost injury, seed source.
Poles and piling	35–50	do	Do.
Logs (lumber, boxes, etc.)	50–60	do	Do.
Pine, pitch:			
Pulpwood and posts	20–30	Good	
Logs	60–80	Fair to poor	Heavy branching habit.
Pine, ponderosa:			
Christmas trees	8–12	Fair	
Posts	20–30	do	
Logs (lumber, boxes, etc.)	70–90	do	Needle-cast fungus serious.
Pine, red:			
Christmas trees	5–8	Fair to good	European pine shoot moth.
Pulpwood, mine props and posts	25–35	Good	Do.
Logs (lumber, boxes, crates)	70–80	Fair	Do.
Pine, Scotch:			
Christmas trees	5–8	Good to excellent	Color, form (seed sources very impo tant).
Pulpwood and posts	25–35	Fair	
Logs (lumber, boxes, etc.)	70–80	Poor to fair	Form, branchiness (seed source ve important).
Pine, shortleaf:			
Pulpwood and posts	20–30	Good	Seed source.
Poles and piling	40–50	do	Tip moth.
Logs (lumber, boxes, etc.)	60–70	do	Do.
Pine, eastern white:			
Christmas trees	7–10	Fair to good	
Pulpwood and posts	25–35	Fair	Branchiness.
Logs (lumber, boxes, etc.)	70–80	Good	Do.
Pine, Virginia:			
Christmas trees	5–10	Poor	Color, form.
Pulpwood, mine props and posts	15–25	Good	Branchiness.
Redcedar, eastern:			
Christmas trees	8–15	Poor to fair	Color, form.
Posts	25–35	Good	
Logs	70–80	do	
Spruce, Norway:			
Christmas trees	8–12	Good	
Logs	60–80	Fair	Site requirements.

[1] The list of species plantable for Christmas trees is not complete; only those that can also be planted for wood products or that can be mixed with species suitable for wood products, are listed.

[2] Special conditions, related generally to the need for a careful selection of stock from specific seed sources, a careful evaluation of the site, or measures to control insects or diseases.

A wide variation in branchiness, taper, crook, and vigor is common among trees in stands. Probably these variations in trees growing in the same environment are in part inherited so that trees grown from seed tend to have the same characteristics of branching habit, form, and growth rate as their parents. It seems desirable, therefore, to collect seed from trees that have the qualities desired in the offspring.

Recent reports indicate that many wood properties affecting suitability for certain products are also inherited (*102*). These properties include such things as length of wood fibers, wood density proportion of summerwood to spring wood in the annual rings, and fibril angles, all of which affect strength, shrinkage or warpage, and pulp quality and yield. There is some evidence that it is possible, for example, to select cottonwood for

TABLE 3.—*Potential products from hardwood plantations in the Central States*

Species and chief uses	Years to produce	Quality	Critical production factors [1]
sh, green and white:			
Pulpwood	30–50	Fair	Site requirements.
Logs (handle stock, lumber)	50–70	Good	Do.
atalpa:			
Posts	15–25	Fair	Form, branchiness.
ottonwood:			
Pulpwood	10–20	Good	Fiber length.
Logs (boxes, crates, lumber, veneer)	30–50	do	Branchiness.
ackberry:			
Logs (boxes, crates, furniture, millwork)	50–70	Fair	
ocust, black:			
Posts, mine props	7–15	Good	Locust borer.
laple, silver:			
Pulpwood	20–30	do	Multiple stems.
Logs (lumber, veneer)	40–60	Fair	Do.
ak, northern red and bur:			
Posts, mine props	20–30	Good	Site requirements.
Logs	60–80	do	Do.
sage-orange:			
Posts and props	15–30	do	
veetgum:			
Pulpwood, posts	20–30	do	Site requirements.
Logs (lumber, veneer, etc.)	60–80	do	Do.
camore:			
Pulpwood, mine props	20–30	do	Do.
Logs (lumber, boxes, etc.)	60–80	do	Do.
alnut, black:			
Logs (lumber, veneer, etc.)	60–80	do	Do.
ellow-poplar:			
Pulpwood, mine props	20–30	do	
Logs (lumber, veneer, etc.)	50–70	do	Site requirements.

[1] Special conditions, related generally to the need for a careful selection of stock from specific seed sources, a careful aluation of the site, or measures to control insects or diseases.

anting that will produce pulpwood with a high oportion of long fibers (*16*). These factors, when known, should be considered in the choice of cuttings or seedlings for planting.

Establishing the Plantation

After species for planting have been selected, e planting job itself must be carefully planned. ow should the ground be prepared? Where is e stock to be obtained, and what about its ality? When should the trees be planted and w far apart? Should they be planted in pure ocks or in mixtures? What methods of planting ould be used, and under what conditions can ed be used instead of seedlings? Success or lure of the enterprise will hinge primarily on e answers to these questions.

PREPARING THE SITE FOR PLANTING

On many sites no ground preparation is needed; some sites it boosts survival and growth; and others it is an absolute necessity. Ground paration is often costly; a study of the need it is therefore an important part of planning ree-planting project.

To survive and grow, a planted tree needs light and certain mineral elements from the soil (*10*). There must also be sufficient moisture in the soil to hold these elements in solution (*67*, *68*) and to maintain growth processes. And finally soil and air temperatures, by their effects on evaporation and water loss of trees (transpiration), also influence survival and growth of planted trees. Three of these important site factors—soil moisture, light, and temperature—can be manipulated to a certain extent by controlling vegetation. The degree of control needed is governed largely by local climate, soil properties, topography, vegetation density, and the species selected for planting (*176*, *177*).

Although site preparation is needed mainly to reduce competition, it is also sometimes needed to control injurious rodents, insects, and diseases. Removing heavy grass and brush cover, for example, helps reduce population of mice and rabbits (*66*); and the severity of blister rust, a serious disease of white pine, can be reduced by

removing the alternate hosts—gooseberries and currants—from the proposed planting site and vicinity.

In general, when it appears that adverse light (and temperature) or soil moisture conditions will limit survival and growth of planted trees, some form of site treatment—before or soon after planting—is desirable. Although usually only one of these factors is limiting, both of them may combine to result in more serious effects. As examples, two experiments in the Missouri Ozarks can be cited: in one, thinned shortleaf pine stands with hardwood understories removed grew much faster than similar stands where the hardwood understory was not removed. In the other (*20*, *74*), planted shortleaf pine released by removing the hardwood overstory grew faster than those that were not released, even though both areas supported a rather dense hardwood undergrowth. In these examples both light and available soil moisture apparently affected tree growth. Zahner has reported similar results for pine stands in Arkansas (*181*).

A light overstory on the other hand, may tend to increase initial survival on sites where transpiration of the planted trees may be excessive. The most common sites of this kind in the Central States are those in western Iowa being invaded naturally by hardwoods. In the early stages of this succession the scattered trees and shrubs protect the interplanted trees from wind and partially shade them. An experiment conducted in Wisconsin illustrates the benefits of partial shade (*140*): first-year survival of jack and red pines under a light aspen overstory on a sandy site was 30 to 40 percent higher than on an adjacent open, sandy site. Although soil moisture during the growing season under the aspen stand was a little lower than that in the open stand, this was more than offset by the lower transpiration rate of the planted pine.

In direct-seeding experiment Phares and Liming (*113*) obtained better germination and first-summer survival of shortleaf pine in the Missouri Ozarks when the overstory was girdled than when the overstory had been clear cut. The partial shade afforded by the slowly dying girdled trees evidently provided some protection from high summer temperatures and dry winds.

On some bottom-land sites too much free water in the soil may be the limiting factor. Here drainage may be desirable to improve growing conditions.

In general, some form of site preparation for planting will always be needed for planting in Iowa (*72*), the northern half of Missouri and Illinois, the northern third of Indiana, and the northwestern part of Ohio. In these areas poor distribution of summer rainfall and highly productive soils that support luxuriant vegetation combine to make both light and soil moisture conditions critical. In the other parts of the Central States where the amount and distribution of precipitation are better, soil moisture is seldom a problem; here the primary concern is the dens of vegetation.

Site preparation is seldom needed on the typ nonstocked abandoned fields (*90*, *163*) (fig. 3, It is needed, however, in bottom lands and good nonstocked farmland where there is a hea continuous sod or dense weed and shrub gro (fig. 12). On cutover and partly stocked la site preparation before or immediately a planting is imperative (fig. 10, *C*); in fact, pla ing on this land should not be considered unl the owner is willing and able to control ov topping vegetation as often as needed.

F-50

Figure 12.—A rank growth of grasses and weeds on op nonstocked lands such as this prairie site in Iowa means so form of ground preparation is needed before planting, s as plowing or the use of soil sterilants. During the first growing seasons it will be necessary to mow periodically use chemicals to keep the planted trees from being overtopp

METHODS OF SITE PREPARATIO

Site preparation for tree planting is done mechanical or chemical methods depending up the complexity and size of the operation, types equipment available, character of the soil, speci and type of cover (*166*).

Mechanical

Plowing

In heavy sod or dense grassland, plowing the most practical ground-preparation metho Drawn by animal or tractor, most farm plows c be used to prepare ground for tree planting. large-scale operations where purchase of equi ment is necessary, heavy plows of the midd buster type, throwing the slice on both sides the furrow, are desirable. Except for poor drained sites, shallow, wide furrows, are bes single- or double-bottomed plows may be use On slopes where gullying may occur, plowi should be done on the contours with furrow slic

on the downhill side. Furrows are usually plowed 6 to 10 feet apart; sometimes, however, the entire area to be planted is plowed or disked, especially in the prairie sections of the Central States. Plowing the entire area of course greatly increases ground preparation costs.

Plowing should be done several months before planting. Trees are usually planted in the bottom of the furrow; however, on wet bottom-land sites the trees should be planted on top of the furrow slice.

Furrowing has some disadvantages (*126*). It roughens the land surface, making walking difficult and hampering the use of some machines needed to care for the plantation. Furrows are also favorite runways for rodents and livestock that may damage the trees.

Scalping

Scalping is done by scraping away heavy surface vegetation from spots 1 to 2 feet square, usually in conjunction with the planting operation itself. Trees are planted in the center of the spot. Scalping, done by hand with hoe or mattock, is tedious and expensive, and the results are usually not as effective as those of other methods that might be used. It should be done only where other site preparation measures are impracticable.

Ripping and Subsoiling

Ripping and subsoiling are seldom warranted or tree planting, although in some cases they nay improve site conditions somewhat by loosen- ng impervious hardpans. The few studies that ave been conducted indicate little benefit from ipping (*89*).

Disking

Although disking is of limited value in tree lanting, there are situations where it is warranted. ne disking is not enough; it usually results in ncreasing the density of the vegetation. On open, oorly stocked land, especially in the prairie grass- nd areas, disking should be used to prepare the round for planting only when it is definitely lanned to cultivate the land after planting (see p. 36 and 38).

On partly stocked land it may be used to prepare ne site for direct seeding (see p. 34) as well as r planting. Disking may be done in narrow rips, with the trees planted in the middle of the rips, or the entire planting area may be disked. eavy disks, equipped with hydraulically mounted bber-tired wheels to permit easy turning on nall areas, are most adaptable to conditions in e region (fig. 13). On light to moderately llied land the disk can also be used to grade rfaces to permit machine planting (fig. 14).

elling and Girdling

Cutting brush and felling or girdling young rdwoods, without the use of chemicals, invari- ly result in vigorous resprouting (*31*). Although

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Figure 13.—Heavy disk, especially adapted to brushy areas and heavy ground cover. Rubber-tired wheels hydraulically mounted, permit raising of disk for easy maneuvering.

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Figure 14.—The disk can also be used to grade light to moderately gullied land (*A*), to permit machine planting (*B*).

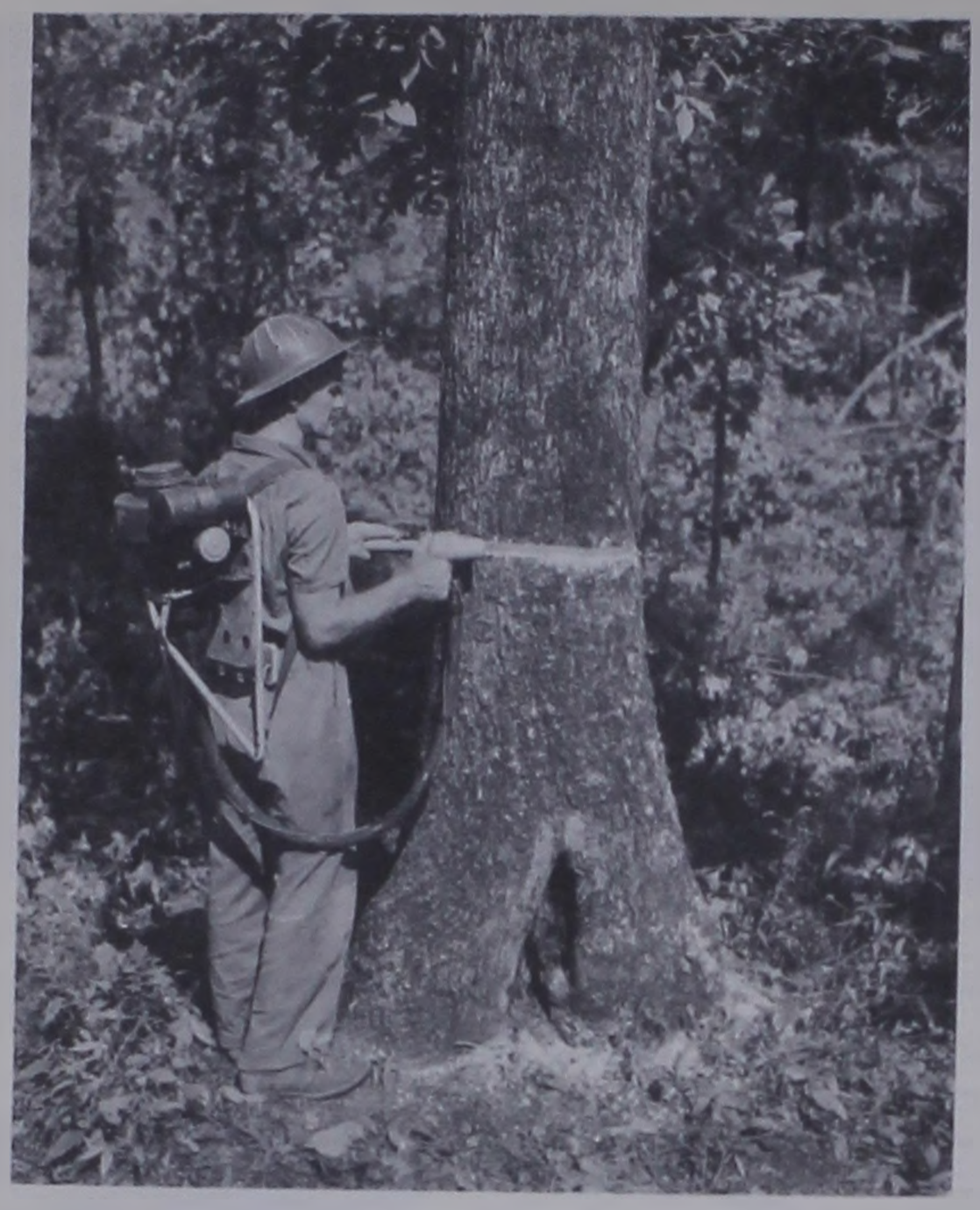

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Figure 15.—The "Little Beaver" can be used for girdling on smooth-barked, single-stemmed trees.

one treatment may be adequate for good initial survival, repeated cuttings after planting are usually needed to maintain satisfactory survival and growth. Brush can be cut with brush hooks, brush scythes, axes, or machetes. The trees may be girdled (*51*) by cutting a notch completely around the tree at a convenient height. The "Little Beaver" (fig. 15) is a useful tool for girdling; sometimes, however, if chemicals are not applied, the girdle made by this machine is "bridged over" with new growth. For best results, all cutting and girdling should be supplemented by chemical treatment on cut surfaces (*88*).

Clearing and Grading

Clearing and grading land with heavy machinery is expensive and should be done only when other methods are impracticable. Some of this is being done by large companies on brushy old fields and on extensive bottom lands for the planting of cottonwood, hybrid poplars, sweetgum, and several other species. One example of a site where clearing and grading appear necessary is an old field that has been taken over by dense thickets of thorny crab apple; another is an area supporting junglelike rhododendron. These thickets would still be impenetrable by planting crews even if the plants had been killed by chemicals.

On brushy old fields, tractors with root-rake attachments (fig. 16) should be used to gouge out strips on the contour and pile the debris in windrows along each side of the strip. Although not necessary, the windrows may be packed with a tractor and burned. The burning, if attempted, should be done before the trees are planted. (3) if a "Bush Hog" is available the debris can be converted to chips (*166*).

Land severely gullied (fig. 17) may need some grading before tree planting. The grading should be done on the contour, creating a series of terraces rather than long, smooth slopes. Stabilization with grass or mechanical structures might also be needed before planting on some actively eroding, severely gullied land.

Chemical Control of Vegetation

Great strides have been made during the past two decades in developing chemicals to eliminate or reduce unwanted vegetation. Costs are continually decreasing so that the use of chemicals is often the most economical as well as the most effective means to prepare sites for planting (*130, 147*). In practice, the chemicals are applied

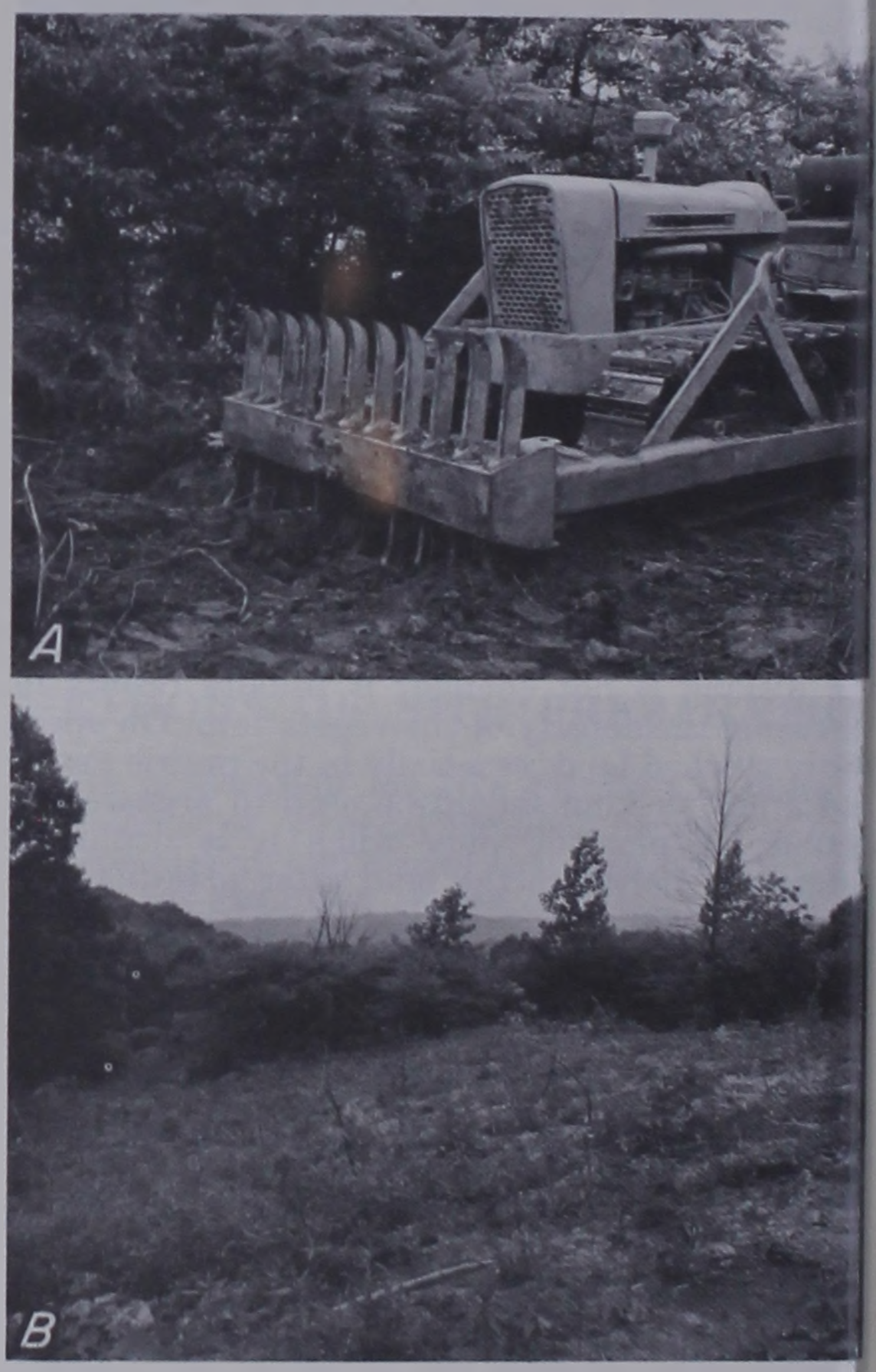

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Figure 16.—*A*, The root rake, attached to the front of a tractor is an effective tool for clearing brush and tree cover from areas such as that shown in *B*. Also, by removing all except the two outermost teeth, the rake can be used to scarify two strips simultaneously for direct seeding old fields.

F-384857

Figure 17.—Severely gullied land may need some grading before planting, especially if planting machines are to be used.

to the leaves of plants (foliage sprays); to the base of stems (basal treatments); to wounds created by frilling, notching, or girdling; to stumps; or to the soil (*3*, *134*).

Control of vegetation by the use of chemicals does not always mean that the treated plants are killed (*86*). Some of the best chemicals now available kill only tops or crowns, but resprouting from the roots or the lower part of the tree may be weakened or delayed enough to allow planted trees to become established and overtop subsequent competing vegetation. Sometimes one or more additional applications are needed.

Chemicals to Use [4]

Chemicals used in vegetation control are of two general types (*141*, *175*), based on their action: (1) the plant hormone or growth regulator type that gains entry through leaf, stem, or roots and disrupts normal growth processes of the plant. The most common chemicals of this type are 2,4–D, 2,4,5–T, MCP, and propionic compounds, such as 2,4,5–TP (Silvex) and amitrol (amino triazole). (2) The contact type that is toxic to plants; water-soluble contact chemicals such as ammonium sulfamate (Ammate), and arsenical compounds are translocated from one part of the plant to another. Others, such as sodium chlorate, the dinitrophenols, trichloroacetic acid (TCA), and some oils, kill plants by contact alone even though not readily translocated to various parts of the plant. A list of the susceptibility of common woody species to herbicides has been published (*154*).

Some chemicals are nonselective and can be used to control many species of plants while others are so selective that they can be used for a single species or a small number of species only. The effectiveness of all chemicals depends on many things, the most important of which are the species, season (*133*) and method of application; dosage (*61*); weather; size and age of tree; and kinds of diluent used (such as water, light fuel oil, diesel oil, or kerosene). In using the chemicals recommended for various types of vegetation control the specific instructions relating to dosage, methods of mixing, and safety precautions should be followed (table 4). (See also "Safety Precautions," p. 23.)

The chemicals listed in table 4 are considered to be the best available for the specified purpose. There have been so many new herbicides developed in recent years that many of the old standbys are becoming obsolete. For this reason, readers may wish to contact their local service forester, county agricultural agent, or State Agricultural Experiment Station before starting large-scale treatments.

Stem Treatments

To kill trees larger than 4 inches in diameter it is best to apply chemicals in girdles such as those made by the "Little Beaver," or in frills or notches cut by an ax. Make these wounds as close to the ground as possible. Any one of a

[4] The identification and description of commercial products in this publication are solely for information purposes. Endorsement of any commercial product is not intended and must not be inferred.

TABLE 4.—*Chemicals that can be used to control vegetation for tree planting*

Method of application	Chemical to use	Dosages, formulations, and seasons of application
FOR HARDWOODS MORE THAN 4 INCHES IN DIAMETER AT BREAST HEIGHT		
On foliage: Aerial sprays	2,4,5-T or 2,4,5-TP (ester) in diesel oil.	2 lbs. acid and 5 gals. fuel oil per ac (late spring to midsummer).
On stems:		
Frills, girdles	2,4,5-T (ester) in diesel oil	12–16 lbs. ahg [1] (any time).
Injections (overlapping applications)	2,4,5-T (ester) in diesel oil	40 lbs. ahg, or follow directions by i jector manufacturer (any time).
On stumps: Sprays	2,4,5-T (ester) in diesel oil	16 lbs. ahg on top and sides of stun (any time).
FOR HARDWOODS LESS THAN 4 INCHES IN DIAMETER AT BREAST HEIGHT		
On foliage:		
Aerial sprays	2,4,5-T or 2,4,5-TP (ester) in diesel oil.	2 lbs. acid and 5 gals. fuel oil per ac (late spring to midsummer).
Mist blowers	2,4,5-T (ester) in diesel oil	2 lbs. acid per acre to make 1 gal. solu tion with oil; emulsify in 4 gals. wate (late spring or early summer).
On stems and stumps: Basal sprays	2,4,5-T (ester) in diesel oil or kero-sene.	12–16 lbs. ahg or 2 pts. (4 lbs. acid pe gal. concentrate) to 5 gals. keroser or fuel oil (any time).
FOR BRUSH (tree seedlings, shrubs, vines, etc.)		
On foliage:		
Sprays	2,4,5-T (ester) in water	In garden-type sprayers: 1 fluid oz. (lbs. acid per gal.) in 1 gal. wate Power sprayers, and backpack spray ers, 2 lbs. ahg in water (late spring t midsummer).
Aerial sprays	2,4,5-T or 2,4,5-TP (ester) in diesel oil.	2 lbs. acid and 5 gals. fuel oil per acr (late spring to midsummer).
Mist blowers	2,4,5-T (ester) in diesel oil	2 lbs. acid per acre to make 1 gal. solu tion with oil; emulsify in 4 gals. wate (late spring or early summer).
FOR GROUND COVER (grasses, weeds, etc.)		
For annual grasses and many broadleaf weeds: Soil treatment before and during emergence of seedlings.	Simazine	Follow directions of manufacturer o consult local agricultural or forestry agencies.
For annual and perennial grasses: Foliage sprays after emergence and before maturity.	Dalapon	Do.
For annual and perennial grasses and many broadleaf weeds: Foliage sprays after emergence and before maturity.	Amazine	Do.
For broadleaf weeds: Foliage sprays	2,4D in diesel oil (ester form) or 2,4D in water (amino form).	1 to 2 lbs. per acre in 10 to 20 gals. (two treatments, early summer and mid-summer).

[1] Acid equivalent per 100 gals.

number of chemicals can be used, depending upon the species, method, and season of application (table 4). Solutions of 2,4,5–T or 2,4,5–TP, in diesel oil, light fuel oil, or kerosene, are the chemicals most commonly used in stem treatments; 2,4–D, alone or in mixture with 2,4,5–T, is also frequently used. Apply liquids liberally, filling frills and gridles to overflowing. Although not recommended for general use in the Central States, Ammate crystals can also be applied to frills, using about a tablespoonful for every 4 inches of circumference (*178*).

For trees smaller than 4 inches in diameter, basal sprays without girdles or frills are effective. For good results, thoroughly soak the root collar and stem just above the root collar.

Stump Treatments

Although basal sprays are usually satisfactory, trees less than 4 inches in diameter can also be

elled and chemicals applied to the stumps. Cutting trees to control vegetation is not recommended, unless the logs are to be sold or used. Apply the chemical liberally on the top and sides of the stump. Stumps of larger trees felled in previous logging operations can be similarly treated. Chemicals should be applied as soon after cutting as possible. Stumps larger than 10 inches may not need treatment. On botton lands and good upland sites, however, larger stumps may sprout prolifically.

Foliage Sprays

Foliage spraying is the most common method of using chemicals to control tree seedlings, brush, grasses, and weeds (*87*). Sprays must be applied after leaves have attained full size but before they turn color in the fall. Late spring and early summer are the best and often the only seasons for effective foliage spraying. Except when mist blowers are used, foliage should be thoroughly drenched. For some species or groups of species one chemical may be most effective, while for other species or group of species another chemical may be best (table 4). Good top-kill is generally obtained, but for some species sprouting from roots may occur 1 to 2 years after treatment. One or more treatments may, therefore, be needed. Various types of pressure tanks and backpack pumps can be used in applying foliage sprays. Motorized spray equipment such as the mist blower, mounted on trucks or towed by animal or tractor has recently come into wide use on large-scale operations where topography permits (fig. 18). On small areas the backpack mist blower is an effective tool (*142*).

Aerial Spraying

Aerial spraying is fast becoming the most practicable method for large-scale vegetation control (fig. 19). It is especially effective in removing large trees where on-the-ground foliage sprays or stem treatments are impractical or too expensive. The use of the airplane in agriculture for seeding and for the control of insects, disease, and weeds has become so widespread that in every State there are firms that do contract spraying. State aviation boards usually have a list of reputable aerial-spraying firms.

Before deciding in favor of aerial spraying, the landowner should consider a number of pertinent factors. First, of course, is the cost in comparison with ground control methods. Costs will vary with the size of the job. Airplane spraying low-grade hardwood stands in Missouri in 1957, for example, cost $7.75 per acre on a 40-acre tract and $4.92 per acre for 800 acres (*124*). A comparable release by hand methods would have cost from $12.50 to $25.00 per acre.

Other factors to consider are the danger of contaminating the air, soil, and water with substances harmful to all forms of life, and the possible damage to vegetation adjacent to the area to be sprayed. The amount of drift varies with wind velocity, type of plane used, altitude of the plane, and kind of chemical. In one

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e 18.—Mist blower, used here to apply insecticides on established plantation, is also an effective machine for making foliar application in vegetation control before planting.

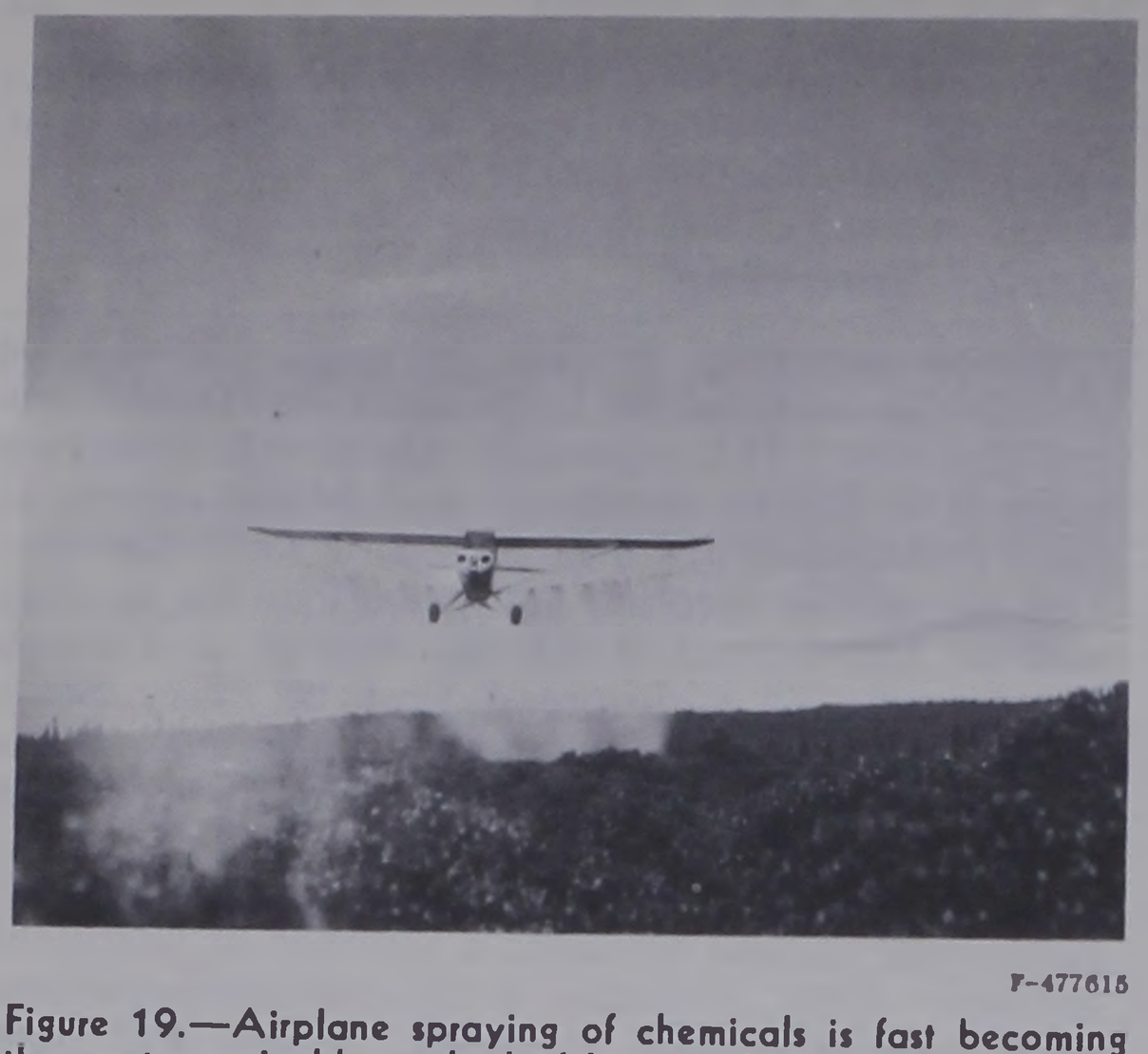

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Figure 19.—Airplane spraying of chemicals is fast becoming the most practicable method of large-scale vegetation control.

operation drift damage in a 5- to 10-mile wind extended for 200 yards to the leeward side of the area sprayed (*81*). On a calm day, drift damage extended no more than 50 yards in the same direction. Recent use of invert emulsions has resulted in still less danger from drift damage.

Helicopters, though more expensive, are better for spraying than airplanes, especially on rough terrain and for spraying small areas. They can generally spray at much lower altitudes than planes.

Before spraying commences, the boundaries of the area to be sprayed should be conspicuously marked and visible from the air. Yellow or orange flags, balloons, or cloth markings on the ground or in trees are commonly used to mark the strips to be sprayed. The best way to mark the boundaries, however, is to apply chemicals in a basal spray or in frills on dominant trees along the boundary 2 to 5 weeks before aerial spraying. Foliage of trees thus treated will turn brown and form a line easily visible from the air.

Soil Treatments

The newest development in the chemical control of vegetation is treatment of the soil. The chemicals, some of which are sterilants, are applied in granular, pellet, or spray form in the spring before the weeds to be controlled emerge. So new is this development that only experimental results are available. Some of these chemicals are Simazine (fig. 20) (*123*), Fenuron, and TCA. Application of some of these, and perhaps of others to come, will no doubt prove to be the most practicable way to control dense vegetation of grasses, weeds, and shrubs. Some planting specialists have ingeniously added tanks and spreaders on planting machines so that chemicals can be applied in strips or spots at the same time trees are planted (*56*). Landowners should review current literature on these developments and consult local agricultural and forestry service selecting and applying these new chemicals.

Mixing Chemicals and Diluents

Except where Ammate crystals or where pe and granules of soil sterilants are specified, chemicals recommended for vegetation co (table 4) are diluted with various quantitie oil or water. The choice of diluent and concentration of the chemical vary accordin the chemical used, the species to be treated, method of application (*115*, *116*). Where are specified, the lighter fuel oils or diesel should be used, not heavy crankcase oil.

Commercial preparations of 2,4-D, 2,4, and 2,4,5-TP are usually available in acid, or ester forms. To minimize damage from c the low-volatile esters are recommended. Wh choice is possible, the ester form is prefe because in general it will give more effective trol than the acid or salt forms.

Containers of commercial preparations ne always bear labels specifying the "acid equival of their contents in pounds per unit volume. the acid equivalent is 2 pounds per gallon example, and you desire a spray with 4 pound acid per 100 gallons of diluent, you would u gallons of the concentrate (table 5).

The diluent and concentrate should be t oughly mixed, and kept thoroughly mixed w spraying. The amount of herbicide actu sprayed per acre will depend as much on the t of spray equipment and speed of operation as concentration of the herbicide. Before begin

F-5

Figure 20.—Simazine, applied as a preemergent broad spray on disked ground in April, effectively contro grasses and broadleaved weeds during the entire gro season. Planted pines were not adversely affected by spray. Note luxuriant vegetation on untreated area background and on sides of planted rows.

arge-scale operations, therefore, run a trial on small measured areas to be sure the appropriate losages are obtained.

TABLE 5.—*Amount of herbicide to use for sprays of different concentrations* [1]

When acid equivalent of herbicide is—	Amount of herbicide when required concentration of spray in pounds of acid per 100 gallons (ahg) is—						
	2	4	6	8	12	16	20
	Gals.	*Gals.*					
2.00 lbs./gal	1. 0	2. 0	3. 0	4. 0	6. 0	8. 0	10. 0
3.00 lbs./gal	. 7	1. 3	2. 0	2. 7	4. 0	5. 3	6. 7
3.34 lbs./gal	. 6	1. 2	1. 8	2. 4	3. 6	4. 8	6. 0
4.00 lbs./gal	. 5	1. 0	1. 5	2. 0	3. 0	4. 0	5. 0

[1] Taken from Station Paper 41, U.S. Forest Serv. Lake States Forest Expt. Sta., by Paul O. Rudolf and Richard F. Watt (*128*).

Safety Precautions

Some of the chemicals used in the control of vegetation are poisonous to people or flammable. Be sure to read the manufacturer's directions for transportation, storage, and use of the chemical, as well as the antidote or first aid instructions in case of accident. Use good "safety sense" in handling chemicals. Remember:

1. Keep safety equipment, first aid kits, extinguishers, and antidotes readily available.
2. Label all containers of chemicals.
3. Use rubber gloves, goggles, aprons, and facemasks whenever they are needed to assure proper protection.
4. *Read and follow the directions of the manufacturer in the storage, care, and use of chemicals.*
5. *Use pesticides with care—read the label.*

WHERE TO GET TREES FOR PLANTING

The best place to get stock for planting is from the State forest tree nurseries. County agricultural agents, local foresters, and employees of the U.S. Soil Conservation Service are always glad to help file applications for planting stock. Or you can write directly to the State agencies listed below for application blanks, prices, and shipping instructions:

State	*Name and address*
Illinois	State Division of Forestry, Dept. of Conservation, 106 State Office Bldg., 400 South Spring St., Springfield.
Indiana	Division of Forestry, State Dept. of Conservation, Indianapolis.
Iowa	State Forester, Division of Lands and Waters, Iowa Conservation Commission, East 7th and Court Sts., Des Moines.
Kentucky	Division of Forestry, Dept. of Conservation, New Capitol Annex, Frankfort.
Missouri	Forestry Division, Missouri Conservation Commission, Farm Bureau Bldg., Jefferson City.
Ohio	Division of Forestry, Dept. of Natural Resources, 751 Northwest Blvd., Columbus 8.

It is wise to order stock about 6 months in advance of planting time to assure a wide choice of species, sources, and ages of stock.

For direct seeding, or when planning for several years in the future, it may be possible to specify that seed be collected from specific trees, especially if good sources are available locally. Seeds and planting stock can also be bought from commercial seed dealers and nurserymen. An up-to-date list of commercial dealers can be obtained by writing to the Forest Service, U.S. Department of Agriculture, Washington 25, D.C.

Unless other sources of known quality are available, the best way to get cottonwood cuttings is to make them from trees of the desired quality near the planting site (see p. 35).

QUALITY OF PLANTING STOCK

The success or failure of a plantation depends to a great degree upon the quality of stock used. Because the development of planting stock varies greatly among nurseries and from season to season in the same nursery, age alone is not an indicator of stock quality. Moreover, plantable stock of most of the species planted is produced in one growing season.

Stock quality should be judged mainly on the basis of size and balance. Stem diameter and length and weight of roots in relation to length and weight of tops are generally considered the most practicable criteria for judging stock quality. Root and top pruning, common practices in nurseries to adapt seedling size to various methods of planting, also affect stock quality.

A few specific studies have been made to determine grading standards in the region. Chapman (*25*) in studying shortleaf pine found that greater stem diameters meant better survival. Similarly, yellow-poplar survival was greater the larger the stem diameter when seedlings ranged from 3/20 to 6/20 inch (*76*). Survival declined in seedlings larger than 6/20 inch when roots were pruned to 8 inches.

Top pruning has no detrimental effect on survival and growth of yellow-poplar and perhaps most other hardwoods; however, some forked trees may develop after top pruning of opposite-budded species such as ash and maple. Packing and shipping are cheaper if hardwood seedlings are top pruned just after lifting in the nursery. And more top-pruned than unpruned trees can be carried in a planting tray.

In most planting, roots are pruned to standard lengths, depending upon the method of planting to be used. Pruning is sometimes done to maximum lengths of only 6 inches when planting bars or planting machines are used, 8 inches when mattocks are used, and 10 inches when long-bladed grub hoes are used. Because the balance of

physiological processes is involved, the degree of root pruning may greatly affect initial survival. Root systems of seedlings severely root pruned may not develop sufficiently before the onset of dry weather to supply water when transpiration losses are high.

To be useful, stock grading standards should be simple and easily applied. They may be used by nurserymen in classifying grades of stock available for planting, or by purchasers in specifying the quality of stock desired. Grading stock is an expensive and time-consuming job for the buyer. If it is found by random sampling that 80 percent or more of the stock in the nursery beds or that received from a nursery meets the preferred standards, grading is unnecessary.

The planting stock grades recommended (tables 6 and 7) for species commonly planted are based on specific studies and on stock measurements taken from trees planted on many experimental areas. For conifers the standards are based on stem diameters (at the ground line) and the relation of top length to root length after pruning. For shortleaf pine, for example, the minimum stem diameter recommended is 5/32 inch; if roots are pruned to 6-inch lengths, the tops should be 4 to 8 inches long. For hardwoods, the standards are based only on stem diameters; maximum stem diameters are prescribed only if roots are pruned to 8 inches or less.

TABLE 6.—*Planting stock grades for conifers commonly planted in the Central States*

Species	Stem diameter at ground line	
	Minimum	Preferred
	Inches	*Inches*
Shortleaf pine	5/32	7/32
Jack pine	3/32	4/32
Red pine	5/32	7/32
Eastern white pine	5/32	7/32
Pitch pine	5/32	7/32
Virginia pine	3/32	4/32
Loblolly pine	3/32	4/32
Eastern redcedar	5/32	7/32

Allowable range in lengths of tops: 4 to 8 inches if roots are pruned shorter than 8 inches; 6 to 12 inches if roots are not pruned shorter than 8 inches.

Take a random sample of the planting stock; measure each tree in the sample, and record the total number of trees measured, the number above minimum specifications, and the number above preferred specifications.

Do not accept stock for planting if sample indicates that less than 75 percent of the trees meet minimum standards.

Grade acceptable planting stock if less than 80 percent of the trees meet the preferred standards. Discard trees not meeting minimum standards.

Acceptable stock need not be graded if more than 80 percent of the trees meet the preferred standards.

In ordering stock for tree planting it is well to specify the grades desired. This will alert the nursery superintendent to your preference and will enable him to serve you better. Most nurserymen have the facilities and personnel to do economical grading job. The intensity of sampling necessary to determine stock quality depends on the total amount of stock and its variability. If less than 75 percent of the sampled trees meet the minimum standards, it is best to reject the stock for planting. If less than 80 percent of the trees accepted for planting meet the preferred standards, the stock should be graded, and the seedlings not meeting the minimum standards should be discarded. The percentage of usable stock in the "Preferred" grade is a good estimate of stock quality.

TABLE 7.—*Planting stock grades for hardwoods commonly planted in the Central States*

Species	Stem diameter at ground	
	Minimum	Preferred
	Inches	*Inches*
Ash, green and white	3/32	5/32
Cottonwood (seedlings) [1]	5/32	7/32
Maple, silver	5/32	7/32
Oak, bur, northern red, and chestnut	5/32	7/32
Osage-orange	4/32	5/32
Sweetgum	5/32	6/32
Sycamore	4/32	6/32
Walnut, black	8/32	10/32
Yellow-poplar	8/32	10/32

Take a random sample of the planting stock; me each tree in the sample, and record the total numb trees measured, the number above minimum specifica and the number above preferred specifications.

Do not accept stock for planting if sample indicates less than 75 percent of the trees meet minimum stand

Grade acceptable planting stock if less than 80 pe of the trees meet the preferred standards. Discard not meeting minimum standards.

Acceptable stock need not be graded if more than 80 cent of the trees meet the preferred standards.

[1] Cuttings of cottonwood and hybrid poplars: dia at small end should be ¼ to ¾ inch; length 12 to 20 in from 1- to 2-year-old dormant stems.

[2] Because cottonwood roots readily, no maximum diameter is needed if roots are pruned to lengths sh than 8 inches.

CARE OF PLANTING STOCK

Improper care of planting stock is often major cause of high initial mortality. When r of many species, particularly conifers, are expo for only a few minutes to sunlight on warm d the trees begin to die and cannot be revi simply by rewatering (*35*). The roots of plan stock must also be protected from freez Stock packed tightly in rolls or bales for more t a week without watering may be seriously inju from heating; stock packed loosely, on the o hand, may dry too rapidly unless watered

uently or stored in a moist atmosphere. It is herefore imperative to protect planting stock om exposure from the time the trees are lifted at ie nursery to the time of actual planting. dequate precautions in lifting and packing stock e taken at most public and private nurseries. he proper care of stock during periods of transit, orage, and planting, is, however, largely the sponsibility of the man in charge of planting.

Transportation of Planting Stock

During transit planting stock should be pro-cted from the sun and drying winds. In open ucks or trailers, the bales or bundles should be vered completely with canvas or similar ma-rial. If these precautions are taken no watering needed during transit periods of less than 12 urs. Shipments by railroad freight should be oided; express shipments are permissible, but rangements should be made in advance to move stock from express offices and warehouses soon as possible. Ideally, stock should be ansported in an enclosed or covered truck or ailer at night when the chances of adverse posure are minimized, and by a driver alerted to e importance of protecting the stock.

Storage of Planting Stock

Trees should be planted as soon as they are ceived from the nursery. Often, however, this not possible. So precautions should be taken protect the stock until it can be planted.

As soon as the stock is received it should be spected; some of the bundles or crates should be ened immediately to check possible damage m heating or drying. The stock should then watered: moisten the interiors of bales and tes, but do not soak or puddle. Do not merse bundles of trees in water until planting e.

If trees are to be planted within a week after ey are received, they may be left in bales or tes but should be kept in a cool, shaded, well-ained area such as a barn, woodshed, root cellar, an improvised lean-to. Moisten the stock daily. If it is necessary to hold trees more than a week ore planting, it is best to keep them in cold rage. Cold-storage facilities are available in ny small cities and towns where eggs and ultry are stored. Many large orchards in the ntral States also have space available in cold-rage warehouses during the spring planting son. If the following precautions are taken, ck can be safely held in cold storage for 4 to eeks:

. Keep temperature at about 33° to 35° F., as stantly as possible—never higher than 40°.

. Do not stack bales or bundles of stock on top each other; place them separately on shelves.

f stock is received in two or more deliveries m the nursery, the date each bundle is placed cold storage should be written on the shipping tag. Stock held in cold storage the longest time should be planted first.

3. Water the stock once each week; watering can be facilitated by attaching a perforated metal tube to the end of a hose, and inserting the tube about halfway into the bale.

If cold-storage facilities are not available and it is necessary to keep stock for more than a week before planting, the trees should be heeled-in; this is done by digging V-shaped trenches in a well-drained, shady location near the planting site (fig. 21). Trees usually come from the nursery tied in small bunches of 25 to 50 trees. Untie these bunches, lay the trees in layers 3 or 4 trees deep along the sloping side of the trench, and then pack soil around the roots. Trees may be removed from the trench as required. The trenches should be kept moist but not soaked. If necessary, most hardwood species can be left heeled-in over winter. Coniferous stock, however, should never be left heeled-in for more than 5 or 6 weeks.

Care During Planting

During planting, trees should be carried in a bucket or planting box and roots kept moist with wet moss, excelsior, peat moss, soil, or other material. Since the roots of baled planting stock are usually intertwined, the trees should be carefully separated before they are placed in the planting-stock container. As an extra precaution against drying, place a piece of water-soaked burlap over the material covering the roots. Keeping the roots moist with these materials is better than placing the trees in buckets of water.

The planter should constantly check the condition of the stock in the container. Careless planters, in pulling out a tree for planting, often partly pull out other trees from the container, thus exposing roots to drying winds and sun.

In large-scale plantings, where several crews are working or planting machines are used, it is good practice to assign to one man the responsibility of packing the stock in containers. When well trained, he can care for the heeling-in bed, receive stock from cold storage or the nursery, and pack stock containers properly for use by the planting crews.

PLANTING SEASONS

Planting should be done during the dormant season, that is, after the hardwood trees have lost their leaves in the fall and before new leaves start in the spring. Soil conditions should be favorable. Do not attempt to plant in frozen or snow-covered ground or when the ground is wet and "sticky." The best time for planting depends upon location within the region.

Except under unusual circumstances fall planting should be avoided. Trees planted in the fall are particularly susceptible to frost heave and winterkill. Frost heaving is especially serious on bare ground and on fine-textured soils such as

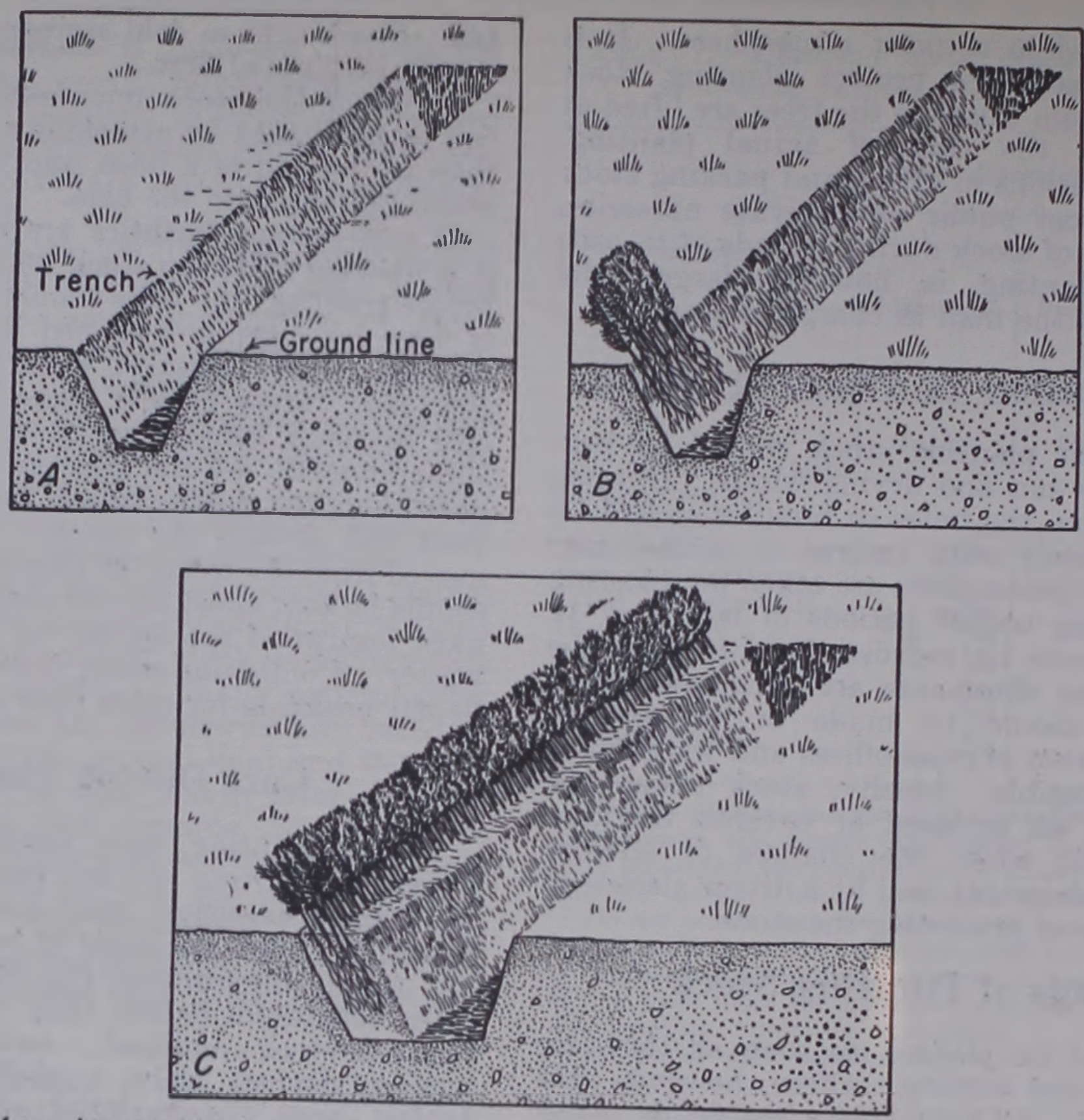

Figure 21.—Method of trenching and heeling-in nursery stock: *A*, Trench is dug deep enough to accommodate roots; *B*, la trees is laid against slanting wall; and *C*, soil is piled and packed against tree roots, leaving trench ready for another of trees to be heeled-in the same way.

Location	*When to plant*
Iowa, northern Missouri, northwestern Illinois.	Spring—about April 1 to May 15. Hardwoods may be planted in the fall, from September 15 to December 1, in heavy cover or coarse soils where frost heaving will be less likely to occur. Do not plant conifers in fall.
Northern Ohio and Indiana, central and northeastern Illinois.	Spring—about March 15 to May 1.
Southern Missouri, southern Ohio, southern Indiana, southern Illinois and Kentucky.	Spring—about March 1 to April 15.

clays, silty clays, and sandy clays. It is not likely to be serious on coarse-textured, sandy soils and on grassy sites that need no ground preparation. There will be less frost-heaving damage if trees are planted on top of the furrow slice than if planted in the bottom of furrows. Winterkill is especially serious when spindly, top-heavy planting stock is used. Sturdy, well-balanced stock is especially important if trees are planted in the fall.

SPACING

Optimum spacing for planted trees has alv been a controversial subject. Lack of conclu research and a misunderstanding of some fac that should be considered have no do contributed to the diversity of opinion on number of trees per acre that should be plan In Europe, where trees have generally b planted at closer spacing than in the Un States, the trend now is toward wider spa (*17*, *42*).

Recent experiments in America (*11*, *18*, *119*, *120*, *138*) have provided general informat on the effects of spacing on growth and form trees. Over a wide range of spacing (4 by 4 9 by 9), at least for periods 5 to 25 years a planting, trees planted at wide spacings gr faster in diameter than those planted at cl spacings. On the other hand, spacing has li effect on total height of species commonly plan in the region. The total cubic volume of wo produced is generally greater in dense stands th in more open stands. But in young stands merchantable volume is usually greater in stan with wide spacings. Logging costs per u

lume of wood decrease with increasing average
e diameter (*109*).

In recommending spacing for forest planting
the Central States the advantages and dis-
vantages of wide and close spacing were
refully considered (table 8). No spacing can
considered ideal or optimum; the decision
ist often be a compromise.

In drawing up spacing recommendations, eight
tors were regarded as most important:

1. *Objectives of planting.*—The kind and quality
products desired should be considered. For
rt-rotation crops, such as fence posts, mine
ps, fuel, and pulpwood, a closer spacing is
essary to get maximum utilization of the site
n if long-rotation crops, such as poles, and
timber, are the primary objectives. For
sion control, where wood products are a
ondary or minor objective, close spacing (6 by 6
by 7) is recommended.

. *Thinnings.*—The possibility of thinning the
ds before the harvest cut is also important in
iding what spacing to use. As a general rule,
thinning should be considered unless it will
for itself either in products removed or in
eased growth of the residual stand (*44*). If
mercial thinnings can be made—and this
ends upon accessibility of area, markets, and
ies planted—a closer spacing is advisable than
inings cannot be made.

Hazards and risks.—There is always the
nce that trees may be damaged or killed
use of adverse site conditions, insects and
ase, windthrow, fire, or grazing. And some
ural operations may even accentuate these
rds. For example, early thinning in a short-
pine plantation can cause an attack by the
us *Fomes annosus* that will result in high mor-
y (*103, 161, 171*). The spacing recommenda-
s given here are based on (1) an expected early
ality of 20 percent due to site and weather
itions, planting stock quality, planting opera-
s, and (2) subsequent mortality as the stand
lops.

4. *Growth rate and stand density.*—One of the objectives of stand improvement is to maintain or accelerate growth and development of the stand by thinning. This does not mean that the rapid growth during the first decade, forming what is sometimes called "juvenile wood," must be equaled in subsequent years. Nevertheless, in extremely close spacing growth reduction and even stagnation may occur before commercial thinnings can be made. Maintenance of good diameter growth until trees attain merchantable size is therefore a factor to consider in the choice of spacing.

Our spacing recommendations are based in part on growth data taken from yield tables in current use. Spacings given are the narrowest possible to maintain good diameter growth until the first cutting. The control of juvenile wood by spacing does not seem feasible. Wahlenberg (*162*), for example, reports that the formation of wide annual rings, largely of springwood, in the first decade of loblolly pine growth cannot be avoided by close spacing. It is quite likely that this response is typical of most of the conifers planted in the region.

5. *Natural regeneration.*—Unless stringent controls are used, natural invasion of hardwoods in plantations is the rule rather than the exception. These volunteers can be left as nurse trees, or to improve the productivity of the site, or they can be taken out as thinnings or part of the final crop. If volunteers are left, the original spacing can be wider, of course. As long as the crowns of the planted trees remain dominant, their growth will not be seriously affected by the subordinate volunteer trees (*106*).

6. *Branching.*—The possible adverse effects of spacing on branching and selfpruning may not be as great as formerly thought. In most pine plantations wide spacing has resulted in slightly larger branches but no significant increase in the number of branches (*48*). And any adverse effect of wide spacing might well be offset by taking advantage of the volunteer hardwood growth

TABLE 8.—*Spacing recommendations for forest planting*[1] *in the Central States*

Rotation and cutting plan	Jack, shortleaf, red, loblolly, and Virginia pines		White pine		Hardwood	
	Spacing	Trees per acre	Spacing	Trees per acre	Spacing	Trees per acre
	Ft.	*No.*	*Ft.*	*No.*	*Ft.*	*No.*
rotation crops—posts, props, pulpwood, , etc.	6 x 8 or 7 x 7	908 or 889	6 x 8 or 7 x 7	908 or 889	8 x 8 or 6 x 12	681 or 605
rotation crops—poles, sawtimber, etc. mmercial thinnings planned.	8 x 8 to 9 x 9	681 to 538	6 x 8 or 7 x 7	908 or 889	6 x 12 to 10 x 10	605 to 436
rotation—no thinnings planned	9 x 9 to 10 x 10	538 to 436	8 x 8 to 9 x 9	681 to 538	8 x 12 to 10 x 10	454 to 436

[1] For erosion-control planting a close spacing is recommended—6 x 6 or 7 x 7 feet. For Christmas tree planting, 5-foot spacing is most common. Jack and Virginia pines should not be planted at spacings wider than 8 x 8 feet.

(*111*). Close spacing, on the other hand, has not eliminated the need for pruning nor significantly reduced the cost of pruning. So, for most conifers the choice of spacing need not be influenced one way or the other by the possibility of branching. For hardwood planting, however, there will most likely be a choice.

7. *Species.*—Spacing recommendations should vary by species, or groups of species, because of inherent differences in growth rate and tolerance. Until more precise information is obtained, however, all pines except white pine have been grouped together. A closer spacing is allowed for white pine than for other conifers because experience has shown that this species maintains good diameter growth at a closer spacing than most other pines planted in the region. For other conifers use spacing recommended for the group if they are *less* tolerant of shade than white pine; use white pine spacing if more tolerant.

Spacings recommended for hardwoods may seem somewhat wide. Hardwoods as a group will not maintain good diameter growth to merchantable size unless thay have plenty of room. If hardwoods are planted close together, they will need at least one noncommercial thinning to maintain good growth. Extremely wide spacing results in heavy branch development on such hardwoods as oak, walnut, and sycamore. The wide spacing recommended applies to these species only when volunteer growth is allowed to develop with but not overtop the planted hardwoods. If no volunteer hardwood regeneration is present or likely to come in, closer spacing is advisable.

8. *Planting costs.*—Planting costs naturally vary with number of trees planted per acre. So it pays to plant no more trees than are needed to meet the objectives of planting. Square spacings are most commonly used, but if machines are to be used in planting and caring for the trees it may be best to alter this pattern to facilitate machine maneuvering. A 6 by 8 spacing is about equivalent to a 7 by 7 spacing, a 10 by 10 spacing is about the same as an 8 by 12 spacing.

MIXED PLANTING

Another decision that must be made early in the planning stage is whether to plant all one species or a mixture of two or more (*129*). Both mixed and pure plantings have their advantages and disadvantages.

Mixed plantings are less likely to be destroyed completely by disease or insects. There is some evidence in this country and in Europe (*17*) that greater yields per acre are obtained in mixed than in pure plantings; and sometimes a market may be found for one species, none for the other.

Pure plantings on the other hand are easier to establish, maintain, and manage; they are often easier to harvest and may result in higher stumpage values. Pure plantings, moreover, are almost invariably invaded by other desirable species through natural stocking, thus minimizing danger of complete losses through disease insects.

If mixed plantings are desired, species sh be selected with great care. First, all sp must be adapted to the site. Second, the sl growing species should be tolerant of shade by faster growing species mixed with them. general, hardwoods are more suitable for rand mixed plantings than pines. If the sp desired do not permit random mixing, and owner wishes to avoid the risk of large plantings, he may resort to block or row-g mixtures (fig. 22).

Mixed planting of conifers and hardwoods almost always unsatisfactory. However, on suitable for yellow-poplar, eastern white white or green ash, and northern red oak ca randomly mixed with the yellow-poplar. sites suitable for black walnut the following sp may be mixed in: northern red oak, white green ash, and sweetgum. If both yellow-po and black walnut are desired, they should planted in small-block or row-group mixt On sites suitable for white pine and loblolly the two may be randomly mixed. Other con should be planted in pure stands or in block row-groups.

INTERPLANTING

The word "interplanting" is used here to de nate any planting on areas that are alre stocked with trees. It includes "underplanti "spot planting," "reinforcement plant "sweetening," and "conversion planting." terplanting is done chiefly to (1) improve stocking and composition of the existing st (2) to utilize the existing stand for the protec and improvement in survival and early deve ment of planted trees (*26*); or (3) because of s emergency it becomes expedient to plant be overstories can be removed. To be success the selection of species and a good understand of their shade tolerances are important.

Interplanting to improve the stocking composition of existing stands is good practice old fields and cutover land partially stocked w trees of desirable species and quality. By pl ing trees in all openings, or in stands with wi spaced trees, the entire area may become stocked. No trees should be planted in sp where they would be overtopped by other t to be left in the stand.

When an overstory is temporarily retai specifically to protect planted seedlings until t become established, the overstory should removed as soon as possible after seedling est lishment is assured. The urgency for remo will vary with species used for planting and si Plantings on productive sites supporting de vegetation will need release sooner than productive sites. Shortleaf, jack, Virginia,

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A. Checkerboard pattern of mixing two or more species by blocks; minimum size block should be 5 rows of 5 trees each.

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B. Row-group pattern for mixing two or more species. Minimum size is 5 rows of the same species to each strip.

Figure 22.—Suggested methods of mixing species in plantations, when random mixtures are inadvisable.

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loblolly pines should be released completely during the first season of planting or as soon thereafter as possible; white pine, yellow-poplar, black walnut, and red oak overtopped by other trees should be released not later than 3 to 5 years after planting. Redcedar, sweetgum, and ash may survive up to 10 years after planting under a dense overstory, but even for these species earlier releases are desirable.

For some species and sites, interplanting areas that have sparse overhead cover may be better for planting than open nonstocked sites. Scattered trees and a light overhead cover may help increase survival of interplanted trees by protecting them from drying winds, moderating soil-surface temperatures, and lowering transpiration losses during dry periods. Taller trees adjacent to planted trees also act as nurse trees to improve form and reduce branchiness. Light shade cast by girdled overstory trees has increased germination and first-year survival of direct-seeded shortleaf pine in the Missouri Ozarks (*113*).

Interplanting small openings in sparsely covered tree or brush stands may also be good practice in western Iowa, where dry, searing winds and high evaporation rates are critical. In other parts of the region, interplantings of species such as yellow-poplar and white pine are usually successful in sparse stands of small, short-lived species such as sassafras, persimmon, and sumac (*99*). It should be borne in mind, however, that other site factors such as soil, topography, and locality, need to be considered as much on sites to be interplanted as on other sites.

PLANTING METHODS

Before 1945 nearly all of the tree planting in the United States was done by hand. Since that time, because of the scarcity and high cost of labor and the many technological advances, most trees—perhaps more than 75 percent—have been planted by machine. With the advent of large-scale machine planting came questions relating to the effects of these new techniques on the subsequent survival and growth of plantations. The results to date show generally that both survival and growth of machine-planted trees are satisfactory.

In a study on an old field in Ohio, where all common methods of ground preparation were used, Merz and Funk (*90*) reported that machine planting was not only the cheapest method used but that both the survival and growth of white pine 10 years after planting were as good or even better than for those planted by hand methods. Today the choice between hand or machine methods of planting is governed largely by size of the job and roughness of the topography, or the density and size of brush, trees, and debris.

In all methods of planting there are several precautions that must be followed:

1. Plant the tree at the right depth; slightly deeper (never higher) than its depth in the nursery; it is easy to see the old ground line on the tree.

2. Plant the tree so that the main root is straight down, not doubled or sharply bent. Trees planted with roots "U-shaped" in the ground grow poorly (*52*). It is better to cut off the ends of long roots than to have them doubled up.

3. Press the soil well about the roots so as to hold the tree firmly in place.

4. Plant trees in an upright position, nearly even with the general ground level, not sunk in a hole, nor (except in wet, poorly drained sites) raised on a mound.

5. Plant only one tree per spot.

Hand Planting

Hand planting is generally done (1) when planting machines are not available, (2) where the planting site is too steep, too stony, too severely gullied, too brushy, or too small to be planted by machine, and (3) where there are spots and small patches that were skipped in machine planting.

There are two general methods of hand planting: the hole (side or center) method (fig. 23) and the slit method (figs. 24 and 25).

The side-hole method (fig. 23, *A*) consists of digging a hole deep enough to hold the roots of the tree. One side of the hole is vertical and the tree is held against this side about ¼ to ½ inch deeper than it grew in the nursery. Loose soil is then packed around the lower roots, the hole is filled, and the soil pressed with the foot. The chief precaution is to make sure that the hole is deep enough so that the roots will not be doubled or bent.

The center-hole method is similar except that the tree is placed in the center of the hole and soil packed around the roots (fig. 23, *B*).

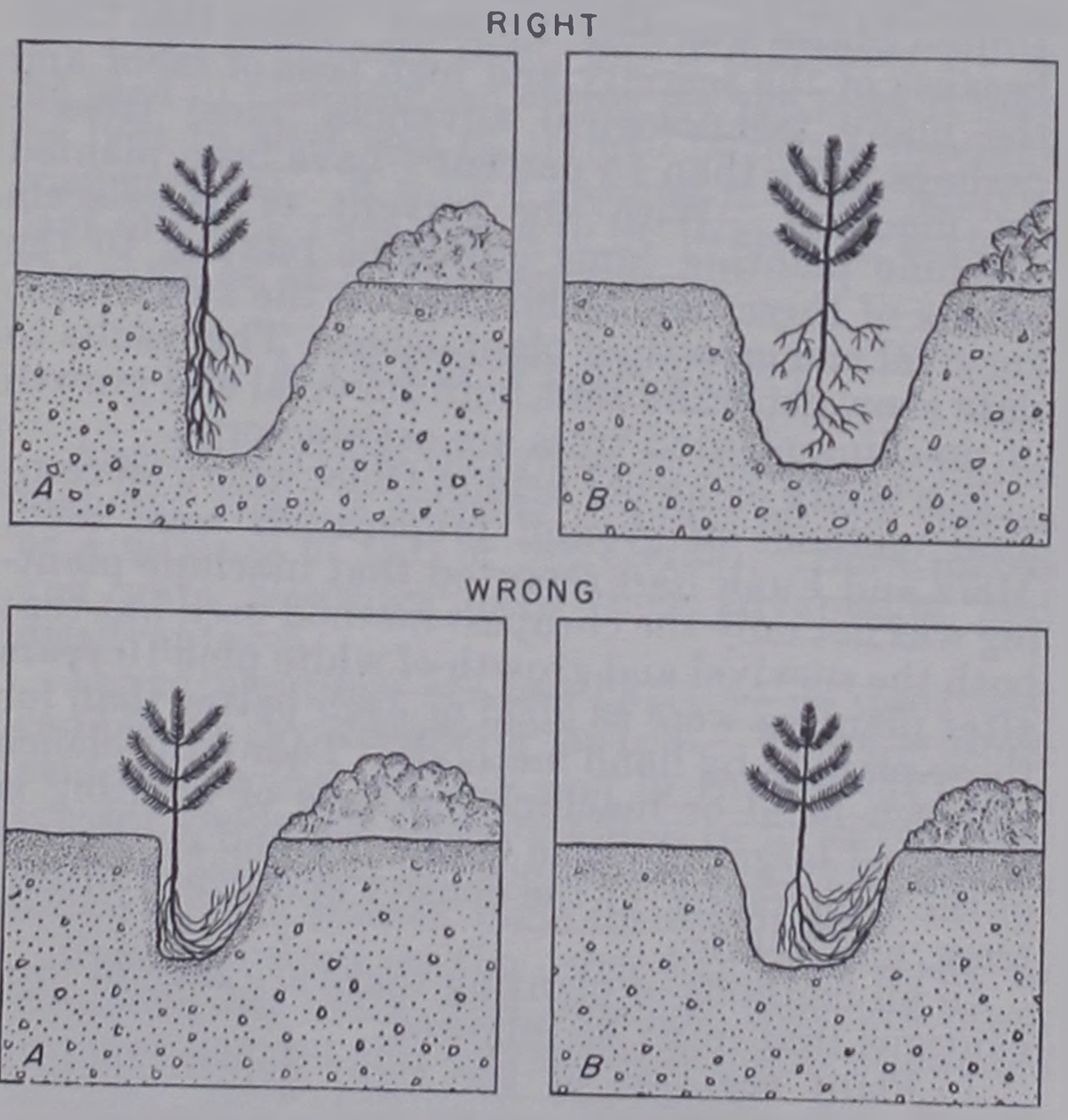

Figure 23.—Right and wrong methods of hole planting: *A*, side-hole method, and *B*, center-hole method (99).

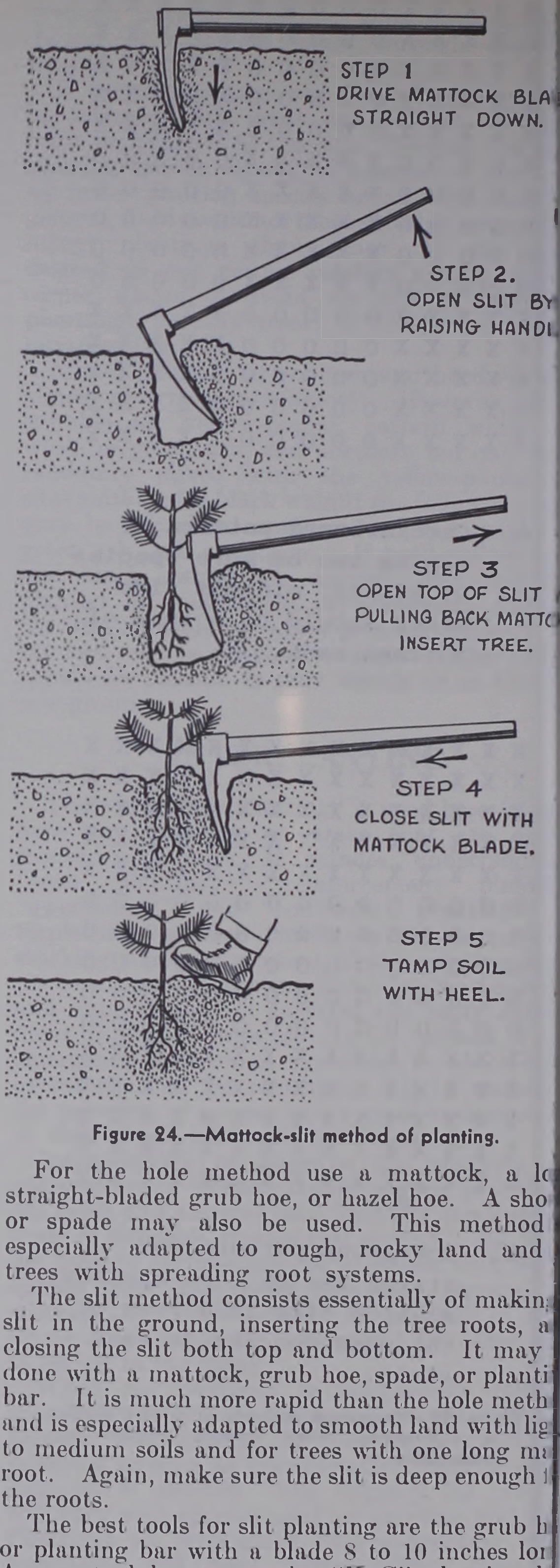

Figure 24.—Mattock-slit method of planting.

For the hole method use a mattock, a l straight-bladed grub hoe, or hazel hoe. A sho or spade may also be used. This method especially adapted to rough, rocky land and trees with spreading root systems.

The slit method consists essentially of makin slit in the ground, inserting the tree roots, a closing the slit both top and bottom. It may done with a mattock, grub hoe, spade, or planti bar. It is much more rapid than the hole meth and is especially adapted to smooth land with lig to medium soils and for trees with one long ma root. Again, make sure the slit is deep enough f the roots.

The best tools for slit planting are the grub h or planting bar with a blade 8 to 10 inches lo A new tool known as the "K–C" planting b appears especially adapted to planting seedlin with well-developed root systems. The bla

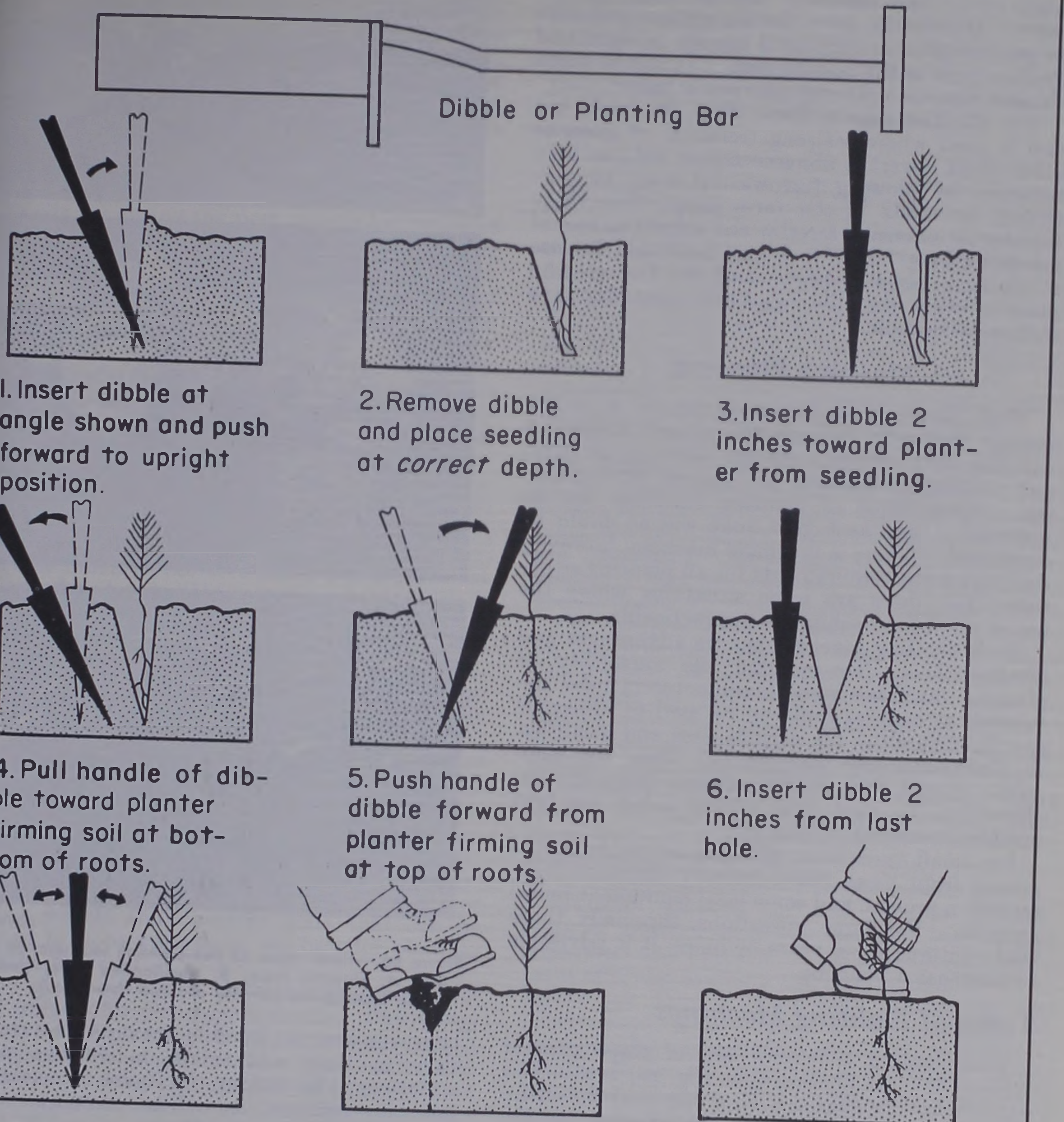

Figure 25.—Bar-slit method of planting. (From Stauffer (*137*).)

should be at least as long as the roots of the trees being planted. If it is not, prune the roots (but leave at least two-thirds the original length), or plant by the hole method. Do not double up the roots. If properly done, the slit method will give as good results for taprooted species on light and medium soils as the hole method. It will be much cheaper because planting goes much faster.

The planting bar is faster than the grub hoe and is used where scalping (removal of grass or other plant cover) is unnecessary or sod has been removed by plowing furrows. It may be purchased or made in the farm shop. The State forester or extension forester can supply names of manufacturers. This tool was developed for use in planting large acreages, and the farmer who plans to plant more than about 20 acres may save money by using it.

Machine Planting

Most planting machines consist of a rolling coulter that cuts through the ground surface, a trencher that creates a slit for inserting the tree, and packing wheels that firm the soil after planting. Many types of planting machines are on the market, and each year more will no doubt be developed. There is no single machine, however, that meets the requirements for all planting situations; and there are some situations where the use of planting machines is impracticable.

Each planting machine has its advantages and disadvantages. To increase the versatility of planting machines some manufacturers have developed accessories that can be used to overcome specific difficulties for various sites and localities. In planning a tree planting job, then, the landowner should first decide whether planting machines can be used, and second, select the best machine available for the job.

For small operations, planting machines can be rented from most State forestry divisions, conservation groups, and some local equipment rental agencies. For large operations, especially those that continue for 2 years or more, it is advisable to purchase a machine.

Types of Planting Machines

Tree-planting machines are of three general types (*125*): the floating type (fig. 26) is attached to a tractor drawbar in such a way that the entire machine can be lifted off the ground by the hydraulic lift on the tractor. The semifloating type has its front end carried by the tractor and its back end carried on wheels; it cannot be lifted by the tractor. The trailer type has all or nearly all its weight carried on its own wheels; this type usually has a coulter and trencher that automatically raise the machine out of the ground over logs and boulders.

Each of these three types of planting machines has its advantages and disadvantages for any particular planting operation. And models of each

Figure 26.—Three types of tree-planting machines in comme use: *A*, Floating type; *B*, semifloating type; and *C*, t trailer type (photo courtesy of Ohio Power Co.).

type, constructed by different manufacturers, als vary in their adaptation to various plantin situations. In making the choice of machines th following features, as well as comparative cost should be considered (*121*):

1. *Ease of operation.*—Comfort of tree planter ease in hitching on to tractor or lifting machin over obstacles; smooth working parts.
2. *Maneuverability.*—Amount of space neede to turn around; adaptability to planting sma patches and corners.
3. *Protection.*—Devices to protect operator fro brush, trees, and other obstructions.
4. *Versatility.*—Adaptation to a number different situations.

5. *Construction.*—Sturdiness; quality and thickness of frame, gears, other parts.

6. *Stability.*—Some machines tip over easier than others; the trencher is more difficult to operate smoothly on some machines than others.

7. *Tractive power.*—Some planting machines will need larger, more expensive tractors to pull them than others; some can be drawn by horses. Wheel tractors are faster to operate on level, cleared land than crawler tractors; the latter are better adapted to hilly and brush-covered land.

Critical Operational Factors

Experience during the past decade has revealed several operational factors that have a bearing on the use and efficiency of planting machines. Some are so critical as to prevent the use of any planting machine, while others are important factors to consider in selecting the kind of machine to be used. Sometimes alteration or slight modification of a machine will make it suitable for the varying conditions from one area to another. The most important of the critical operational factors are size of area, topography, character and density of cover, and soil conditions.

Size of area.—On small areas (less than 5 acres) where frequent turning around will be necessary, it is better to use a floating type of machine; otherwise much of the area along the edges must be planted by hand. It is not practicable to plant areas less than 1 acre by machine.

Topography.—Topography is one of the most important site factors limiting the use of tree-planting machines. Most of the planting machines now available cannot be used effectively on steep, rough land.

When planting along the contour, the slope of the hill affects the angle of the trencher and the stability of both planting machine and tractor. Whether a tree is planted in an upright position or on a slant depends on the angle of the trencher. Machines that have three-point hitches and hydraulic cylinders controlling the trencher, or packing wheels and operator seats that can be adjusted to slope variations, are best for planting along the contours.

Crawler-type tractors are better and safer than wheel tractors for planting on slopes. Depending upon type of planting machine and tractor, a safe maximum slope for contour planting is 10 to 15 percent on rough ground, 15 to 20 percent on smooth ground. (A 10-percent slope means a rise of 10 feet for 100 feet horizontal.) With the use of specially designed equipment, consisting of a self-leveling and hydraulically operated plow and planting machine, the Muskingum Conservancy District in Ohio has contour-planted slopes as steep as 50 percent.

Planting across contours (up and down slopes) can be done on steeper slopes than planting along contours and is limited mainly by tractor power. On steep slopes it is possible to plant only while proceeding downhill, but this is still cheaper and easier than hand planting. Crawler tractors or wheel tractors with half tracks should be used for planting up or down slopes. Up or downhill planting is limited to sites where no ground preparation is needed or to sites where scalping is feasible. In the latter case, a planting machine with scalpers is desirable. However, no ground preparation is needed on most of the hill plantings on old fields in the southern parts of the Central States.

Character and density of cover.—On open, poorly stocked land with a heavy sod cover, where no ground preparation is planned, the use of planting machines with furrowing or scalping attachments should be considered. On partly stocked land (see p. 5 for definition) the use of heavy, trailer-type planting machines is nearly always needed. If cover is dense, or if there is much debris on the ground, hand planting or the use of a pusher plow attached to the front of the tractor (*122, 127, 131*) is necessary. Machine planting is impracticable on most cutover land in the Central States.

Soil condition.—Texture, stoniness, and moisture content of soils have an important bearing on the effectiveness of machine planting. These factors need to be considered in choosing planting machines and tractive power for large-scale planting operations. Sometimes the effectiveness of machines can be improved by the addition of accessories or the removal of some standard parts.

On stony soils the coulters of some machines do not function properly. One operator solved this problem on an extremely stony bottom land in Illinois by removing the coulter; after the coulter was removed the shoe had no difficulty going through the stony soil at about the right depth. When machines are used in planting on stony soils, it is advisable to have a man follow behind the machine to dig up and hand plant those trees not properly planted by the machine; where conditions are such that many trees have to be replanted, machines should not be used.

Machine planting in wet clay is difficult. Crawler tractors generally perform best in this situation; one operator in Illinois found that a team of mules towing a trailer-type machine did a better job than a wheel-type tractor on wet bottom-land soils. Most of the difficulty in machine planting wet clay soils is due to improper slits made by the trencher and packing wheels becoming clogged with mud (*65*). Machines with large packing wheels (12 to 15 inches in diameter) work better on these sites than those with the smaller ones. Fox (*46*) has improved the performance of planting machines in this situation by adding a larger auxiliary wheel to the rear of the planting machine to absorb the extra pressure when packing wheels hit soft ground; this also is helpful in coarse, sandy soils.

In general, machine planting on wet clay soils is easier on land where no ground preparation has been done than on furrowed or cultivated land. When two or more different sites are to be planted

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it is better to plant the coarse, sandy soils during wet weather and the fine-textured soils during dry weather. It is better to keep stock in cold storage for as long as 5 weeks until soil moisture conditions improve than to plant in wet, muddy, clay soils.

The Machine Planting Job

As much vigilance is required to get a good job of machine planting as is required for hand planting. On dry, sunny, windy days great care must be taken to see that roots of trees are kept moist. Use a soaked piece of burlap over the container from which trees are withdrawn for planting. Machine performance should be constantly checked. Measure the operating depth of the trencher frequently. Dig up a number of trees each hour to see if depth of planting and soil packing are correct.

Planting stock for machine planting must be of uniform size and high quality. Both small and large trees are hard to plant properly. All trees should, if possible, be of a preferred grade (see tables 6 and 7, p. 24). Except for opposite-budded species such as ash and maple, hardwood seedlings may be top pruned to facilitate planting. If hand planting is also planned, use the smaller trees of acceptable grades for this job.

A three-man crew is generally used in machine planting: a tractor operator, tree planter, and tree packer. When all three men are qualified, the men on crews switch jobs to reduce fatigue. As with all mechanical operations, daily maintenance of equipment and a ready supply of spare parts will reduce the number and duration of breakdowns.

Safety Precautions for Machine Planting

The following safety rules, adopted by the U.S. Forest Service (*157*) may well be considered in planning and supervising machine-tree-planting operations.

"(1) Machine shall be provided with foot guards that completely cover the bottom and sides of the feet. These guards should be checked frequently for any signs of breakage or other damage.

"(2) A heavy screen guard shall be attached to the planter, to protect the operator when planting is being done in heavy brush. The rear should be unguarded so the operator can get out quickly in an emergency.

"(3) If planting is being done in rough terrain, or in areas of logs or heavy brush, the machine that pulls the planter shall be equipped with a V-shaped blade or angle dozer.

"(4) A signal device such as a buzzer or rope-pull shall be provided for the machine operator and the tractor driver. The signal for a stop shall be definitely understood by both operators. Or a device may be installed on the planting machine to allow the machine operator to disengage the master clutch on the tractor or to release the planting machine from the tractor i case of emergency.

"(5) Operators shall wear close-fitting clothing hard hats, and goggles or other adequate ey protection if the machine is not adequatel screened.

"(6) Operators shall watch for sticks, logs, o brush that may poke up through openings in tb machine.

"(7) The power unit drawing the plantin machine shall be confined to limited degree turn to prevent tipping over the planting machine

"(8) All tractors shall be equipped with upright exhaust pipes to direct exhaust gases away from tractor and planting-machine operators.

"(9) All tractor planting-machine outfits shal be equipped with a first-aid kit (snake-bite ki where appropriate), shovel, ax, and fire ex tinguisher. A rearview mirror should be mounted on the tractor."

DIRECT SEEDING

Recent studies in the Central States have demonstrated that direct seeding of pines, oaks and walnuts can be successful. In the past the principal factors limiting success of direct seeding have been drought and predation by birds and rodents for pine, and pilferage of seeds by squirrels and other mammals for oak and walnut. Losses from these causes can be reduced by the proper selection of sites, site preparation, and adequate protection of the seed. Best results from direct seeding can be expected on cutover and partly stocked land, and then only if sites are suitable for the species used. Recent, but incomplete research indicates that yellow-poplar may also be direct-seeded on this kind of site.

The advantages of direct seeding are as follows: (1) It may be much cheaper; (2) the landowner can sometimes collect his own hardwood seed, thus saving money and making sure that his trees are from local stock; (3) seeding can be done even if planting stock is unobtainable; (4) as seeding may sometimes be done in late fall, while planting is best done in the spring, the workload can be better distributed; and (5) the more natural root systems of seed plantings usually insure better trees.

Pine Seeding

Direct seeding pine has one big disadvantage. In a dry year it may be a nearly complete failure; drought is the greatest obstacle to success with direct seeding of pine. It usually is risky business to direct-seed any of the pine species in heavy broomsedge, because in addition to drought such sites are almost always infested with mice that eat the seeds or seedlings. Some losses to other rodents and birds also occur.

In general, pine seeding is most suitable on sites recently logged over, where much of the soil has been loosened up, on areas that have been recently

urned, or on areas scarified by disking or by ragging a treetop over most of the area (fig. 27). n these sites in the Missouri Ozarks, seeding in te fall or early spring has been most successful; early spring seeding is desired, stratified seed ould be used. But whether sown in fall or ring the seed should first be treated with bird d rodent repellents.

So rapid have new techniques in seed treatments d methods of direct seeding been developed that andard practice today may be outmoded in a ort time. Best techniques and methods in rrent use have been adequately described by ann (*84*) (See Appendix, p. 62).

Oak and Walnut Seeding

The essential steps in establishing oak and lnut by direct seeding are as follows:

1. Collect seed by gathering sound acorns or lnuts from the ground underneath trees. For l oak and several other oak species, bad acorns y be separated from good ones by dumping em all in a tub of water: the sound acorns sink d the defective ones float. Although it is not cessary to husk walnuts, they are easier to ndle when this is done; when husked and dried y can also be tested for soundness by floating water.

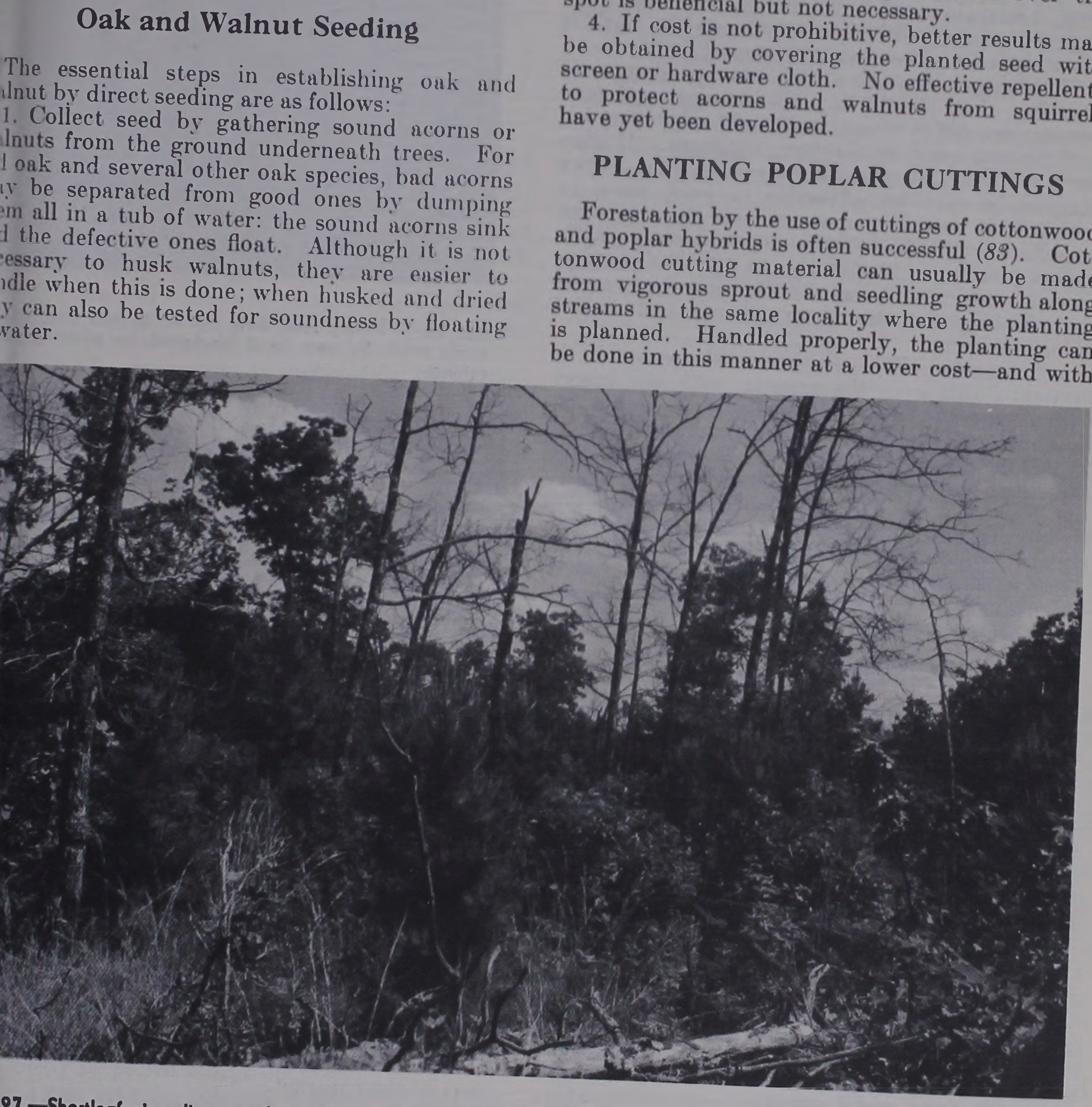
2. Seed in the fall any time after the seeds are collected. But if rodents are a problem, spring seeding is better. To store over winter, the acorns and hulled walnuts should be mixed with moist sand, peat, or a light loamy soil and left outdoors or kept humid in cold storage over winter. Acorns should not be allowed to dry out before planting. Many seeds, either walnut or oak, planted in the spring may not germinate until the following spring.

3. Make holes with a hoe, or a dibble, and insert two acorns or walnuts in a spot, several inches apart. Cover to a depth about equal to the diameter of the seed. A light mulch over the spot is beneficial but not necessary.

4. If cost is not prohibitive, better results may be obtained by covering the planted seed with screen or hardware cloth. No effective repellents to protect acorns and walnuts from squirrels have yet been developed.

PLANTING POPLAR CUTTINGS

Forestation by the use of cuttings of cottonwood and poplar hybrids is often successful (*83*). Cottonwood cutting material can usually be made from vigorous sprout and seedling growth along streams in the same locality where the planting is planned. Handled properly, the planting can be done in this manner at a lower cost—and with



27.—Shortleaf pine direct seeded on a cutover upland hardwood site in the Missouri Ozarks. A good oak-pine stand appears to be developing. F-502346

better results—than with seedlings of possible distant seed origin obtained from a nursery.

The cuttings should be made during the dormant season, preferably just before planting time. Select cuttings from vigorous sprouts or seedlings; they are usually most abundant on sandbars along streams and other lowlands flooded periodically. Although stems 2 years old are permissible, it is best to make most of your cuttings from parts of the stem 1 year old. Make the cuttings from branches as well as the main stem but do not use the tips of either. Cuttings should be at least ¼ inch in diameter, preferably from ⅜ to ¾ inch. They should be at least 12 inches long, preferably 15 to 20 inches. The cuttings should be made with sharp tools, so the bark is not stripped or loosened in the operation.

If cuttings are made a long time in advance of planting, they should be tied in bundles of convenient size (25 to 50 cuttings) and buried in moist, well-drained sand or sawdust, outdoors. If they have to be transported long distances before planting it may be advisable to pack them in moist moss or sawdust, or to coat the tips with paraffin to prevent them from drying (*148*). Before planting it is advisable to soak the cuttings in water for 1 or 2 days (*148*). For best results the planting site should be cleared and disked before planting.

In planting, the cutting should be set in a vertical position in the ground, with the larger end at the bottom; the smaller end should be flush with the ground surface, or not more than 2 inches above the surface. A planting rod (fig. 28), easily made by a local blacksmith, is the best tool to use for planting; the cutting should extend to the bottom of the hole and should be tamped with the heel of the shoe. Areas planted with cottonwood cuttings must be cultivated at least twice during the first year and once during the second year.

USE OF WILDINGS

In many woodlands and old plantations there are openings with an overabundance of natural reproduction. Some of these "naturals," if suitable for the site to be planted, can be dug up with spades and used in planting. Quite often, however, the overall costs of planting wildings will exceed costs of planting trees obtained from nurseries. Care should be taken that the roots of these seedlings do not dry before planting.

CONTRACT PLANTING

Some landowners may prefer to contract all or parts of a tree-planting operation. A contract can include planting surveys, ground preparation, purchase and transportation of stock, and planting. On some small plantings, especially where the landowner and contractor know each other well, an oral agreement or a simple, written, in-

Figure 28.—Planting rods, from ½- to ¾-inch iron, ca easily made by your local blacksmith for planting p cuttings.

formal memorandum of agreement will suff On large-scale operations, however, it is desir to execute formal contracts with the aid of attorney. The local county agricultural ag or public forestry and soil technicians can usu supply a list of consulting foresters or ot reputable organizations that do contract planti

The legal procedure for drawing up contr no doubt varies somewhat in each State. Th are, however, certain standardized provisi that the landowner should consider in making contract. Some of these are obligations alw assumed by the owner; others, depending u the phases of the operation the owner wishes contract, are obligations of the contractor. obligations of both owner and contractor sho be clearly set forth in the contract.

Obligations of the Owner

1. *Payments.*—Owner agrees to pay the c tractor (a) a specified sum for the planting surv (b) the cost of trees and transportation, usu at a specific rate per thousand trees; (c) the c of ground preparation, usually at a specified r on a per-acre basis; and (d) the cost of planti usually at specified rates per thousand tre Payments to be made after completion of contr or specified amounts upon completion of e part of the contract.

2. *Access.* The owner agrees to provide contractor all rights of ingress and egress to

planting site for all men, materials, and equipment necessary to perform the job contracted.

3. *Planting stock and equipment.*—If not included in the contract, the owner agrees to furnish the contractor the planting stock, supplies, and equipment, at a specified time, for completing the job contracted.

4. *Maps and location data.*—If a planting survey is not to be included in the contract, the owner agrees to provide the contractor a sketch map showing the location of the planting area, with each area properly identified as to species to be planted, spacing, and mixture. If the owner wishes to include a planting survey in the contract, the owner agrees to furnish the contractor the legal description of the parcel of land to be surveyed for planting.

Obligations of the Contractor

1. *If planting surveys are included in contract.*—Contractor will make a planting survey of the parcel of land specified by the owner. The planting survey will include a site evaluation of the land for planting, delineate (a) areas in need of planting, giving acreage and location on a sketch map; (b) area in each planting-site class; (c) number of trees and species to plant on each planting site; spacing, planting methods, and mixtures to use; and (d) site preparation needed.

2. *If site preparation is included in contract.*—Contractor will furnish supplies and equipment needed to complete the ground preparation specified in the contract; contractor will complete the specified ground preparation work. Specification should include time work is to be done, types and methods of ground preparation, such as furrowing, disking, and the use of chemicals to control vegetation.

3. *If stock purchases and deliveries are included contract.*—Contractor will obtain the quantity stock of each species specified by the owner; ock will be of seed origin, variety, and quality ecified by the owner. Stock will be delivered planting site in good, plantable condition; wner reserves the right to inspect planting stock destination, and to reject all trees that appear have been damaged in transit by heating, eezing, or desiccation.

4. *If planting is included in contract.*—The ntractor agrees to abide by the following general ecification, with a tolerance factor not to exceed percent:

a. Trees will be planted at spacings specified in ntract.

b. Trees will be planted slightly deeper than anted in the nursery.

c. Trees shall be firmed with mineral soil cked in and around the roots, so that they cant easily be pulled out of the ground.

d. Trees may be planted by hand or machine thods.

e. Trees must be planted in such a manner that roots will not be twisted, balled, or bent in "U" or "J" shapes.

f. Roots of planting stock must be kept moist at all times prior to and during the planting operation.

g. Except for the lengths specified, roots of trees will not be pruned or cut by the contractor.

h. Trees will be planted on the area specified by the owner.

Protective Clauses and Penalties

1. *Damages.*—Contractor agrees to repair, replace, or pay for damage done to any property in the performance of the contract, beyond ordinary wear and tear. In case of failure of the contractor to repair damage to property, the penalty shall be equal to the cost of having the repair done by another contractor.

2. *Delays caused by owner.*—The owner shall pay the contractor at the rate of a specified sum for each day's delay, for any delays in the planting operation caused by the owner, or his assignees.

3. *Failure to complete planting.*—In case of failure of contractor to complete by the closing date of the planting season the number of trees and areas specified in the contract, penalty shall be forfeiture of payment in the amount needed to complete the planting.

4. *Arbitration.*—Where differences occur between owner and contractor on the amounts of penalties to be assessed, they shall be resolved by a mutually accepted third party, who shall act as arbiter and whose decision shall be final. One-half of arbiter's fee will be paid by the owner, one-half by the contractor.

5. *Survival.*—The criterion for satisfactory planting will be a survival of at least 80 percent of the trees planted by June 1 of the first growing season. When the survival at this date is in dispute the decision will be vested in the arbiter.

PUBLIC AID FOR PLANTING

Because of the growing need for forest products and good land use in our economy, Federal, State, and some local public agencies provide some aid in forest planting on privately owned land. Public aid usually consists of furnishing planting stock at nominal prices, technical assistance, and funds to partly finance the planting operation.

All of the States in the region, financed partly by Federal funds granted under the Clarke-McNary Act (*152*), furnish planting stock at prices equal to or slightly above production costs. Although restrictions vary somewhat from one State to another, trees purchased for forest planting may not be used for landscape or ornamental purposes, nor for growing Christmas trees as the principal crop. In some States favorable tax laws may be applied to land planted to trees (*170*).

The Cooperative Forest Management Act of August 25, 1950 (*152*), authorized the Secretary of Agriculture "to cooperate with the States to enable them to provide technical services to private forest landowners." Under this act a number of farm or service foresters are located at various places in each State to advise landowners on tree-planting practices as well as forest management and timber marketing.

Financial assistance in forest planting is som times furnished by the Federal Government programs designed mainly to promote good co servation practices or to control the producti of farm crops. Information on this kind of assis ance can be obtained from the State foreste county agricultural agent, or local Department Agriculture representative.

Early Care of Plantations

Although plantation management is not within the scope of this publication, it is necessary from the standpoint of plantation establishment to point out the need for early care and protection. Indeed, the early care needed on certain sites and the owner's ability to perform these operations are factors to be considered before deciding whether the site should be planted. For some species and sites, plantation care is costly; on areas where it is generally needed, costs range from one-third to one-half of the planting costs.

On many sites little or no plantation care is needed, but on others it may well mean the difference between success and failure. On prairie soils with a dense cover of brome grass or bluegrass, cultivation during the first and second season after planting may be needed. A study of the need for early plantation care is therefore desirable; it should be made at the time the site is examined for planting and immediately after the planting job is completed.

Early care of plantations includes, mainly, measures to release the planted trees from competition and measures needed to protect the plantation from fire, grazing, disease, insects, and rodents.

PLANTING RELEASE

Two kinds of plantation release are generally recognized: low release, which includes the removal or killing of such cover as weeds, grass, and brush; and high release, which refers to the removal of trees overtopping the planted trees.

Low Release

Low release is needed on those sites where low cover, such as grasses, weeds, and brush, is so dense that it will seriously affect the chances of survival and good growth of the planted trees. Nearly all the planting of conifers on cutover and poorly stocked land will need some low release, at least during the first growing season. If a good preplanting release is done, such fast-growing species as sycamore and yellow-poplar, when planted on suitable sites, generally need no further release. Low release will generally be needed on open, poorly stocked land where site preparation has been necessary (page 16); it will seldom be needed on the typical old field where no site preparation was needed. La spring or early summer is the best time t begin low release; second and succeeding releas should be made later only if needed.

On small plantations, or on large plantation where release is needed on a few scattered patche low release can be done by hand methods, usin sickles, scythes, or hoes. On larger plantation where the cover consists mainly of grasses an weeds, mowing is perhaps the best method low release. Large rotary mowers have bee quite satisfactory for this work (fig. 29). It important that the mowing be done before th vegetation gets so tall that the planted tree cannot be seen during the mowing operation Control of grasses and weeds by the use of newl developed chemicals may ultimately prove th best and cheapest low-release method, however

On plantations located on prairie soils, wher sites have been prepared by disking, low releas can be done by cultivating. Equipment generall available on the farm for cultivating farm crop may be used for low release on these sites. Culti vation is also necessary on bottom-land planting of cottonwood, especially if cuttings were use for planting.

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Figure 29.—One type of rotary mower used extensively for the control of grass and weed cover in plantations.

On cutover and partly stocked land and some old fields, where low cover consists mainly of brush (briars, sumac, laurel, etc.) and tree sprouts, chemical methods of control are best (see p. 18 and table 4).

High Release

To assure good survival and growth of planted seedings, trees overtopping them must be removed; and the sooner this release is done the better (*20*). Except where a light, partial shade for direct seeding is desired, or where interplanting is planned, it is better to completely kill the overstory before planting than to delay this work until after planting. If the overstory is removed first, most plantings on cutover or partly stocked land may not need any high release, or only a relatively cheap "mop-up" release. On good sites, where vigorous sprouting occurs, an additional release 4 to 8 years after planting may be necessary. Landowners will do well to consider the costs of these releases before attempting to plant on such sites.

Large coniferous plantations established under a partial hardwood overstory can be released best by aerial spraying, because the coniferous trees are not affected if recommended chemicals and concentrations are used. Planted hardwood seedlings, however, must be released by treating only the individual tree or shrub to be removed.

Before high release is made it is sometimes desirable to make a tally of the overstory and the planted trees. If more than 75 percent of the planted trees are not overtopped, high release is perhaps not worth the expense (fig. 30). Also, some of the trees overtopping the planted trees may be desirable species, of good form, and potentially better final crop trees than those that were planted. It would be foolish to remove trees of this kind. A mixture of planted and volunteer trees is often a good objective of forest management.

PROTECTION OF PLANTATIONS

Forest plantations should be protected from fire, grazing, rodents, insects, and disease. Periodic examinations followed by quick remedial measures may prevent total loss of the plantation or reduce control costs later. If diagnosis is difficult (*112*), or practical control measures not known, the local service forester or county agricultural agent should be consulted. Or, send reports or samples of damaged plants to a research agency, the State forester, or the State extension forester. Plant material can be kept relatively fresh and moist by wrapping in aluminum foil or waxed paper.

Insect specimens should be preserved, in most instances, in 70 percent alcohol (ordinary rubbing alcohol is suitable) before shipment. Live insects may not be sent through the mail. Shipment of live plant material to other States is regulated by State plant quarantine authorities. An explanatory note should accompany any material shipped. The note should contain the collector's name and address, where and when the samples or specimens were collected, and the name of the plant, if known.

It is essential that the tree plantings be protected from fire. This can be done partly by careful handling of brush fires, grass fires, smokes, and matches. If the planting is adjacent to a road or railroad, a strip 10 to 15 feet wide should be plowed around it and kept fresh by disking as necessary. To prevent erosion, avoid, if possible, having the bare fire lanes run up and down a slope. Repeated disking and serious erosion can, however, be avoided by seeding a perpetually green crop, such as fescue or ladino clover, in the fire lanes.

Cattle, horses, sheep, or hogs can ruin a plantation by browsing, trampling, uprooting, and breaking the trees. Livestock should be kept out of plantations; the fences should be maintained permanently, because heavily grazed woodlands deteriorate rapidly and are neither good pasture nor good forest.

Measures for rodent control are generally expensive and difficult; unless severe losses are apt to occur, control measures are not warranted. Damage from mice and rabbits can be reduced by eliminating their favorite habitat—dense grass and brush—by mowing or applying herbicides. Mice populations in small plantations may be reduced by the use of poison baits, such as strychnine alkaloid or zinc phosphide (*139*); intensified hunting may reduce rabbit populations. Small plantations may also be protected from rabbits by the use of repellents (*59*).

The greatest hazards to tree survival are outbreaks of insect pests or disease. The chances of loss from them can be reduced somewhat by the careful choice of species for each site, good planting practices, and adequate vegetation control. For example, in localities where the white pine blister rust is known to be serious, avoid planting white pine on sites where currants and gooseberries grow unless these plants can be permanently eradicated. Planting redcedar within a mile of apple or pear orchards may result in damage to both the redcedar and the orchards by the cedar-apple rust (*12, 14, 114*). Improper planting, resulting in a mass of tangled roots, may increase the possibility of serious root rots (*60*); and planting red pine in climates different than the climate of its natural range often results in severe attacks by the European pine shoot moth (*Rhyacionia buoliana* Schiff).

It is beyond the scope of this bulletin to give a detailed account of all plantation insect pests and diseases. The appendix lists some of the insects and diseases most likely to be encountered (pp. 64 and 65). The references listed give more details on the identifying symptoms and possible control measures. Obviously, the status of insects and diseases that may be considered of little or no

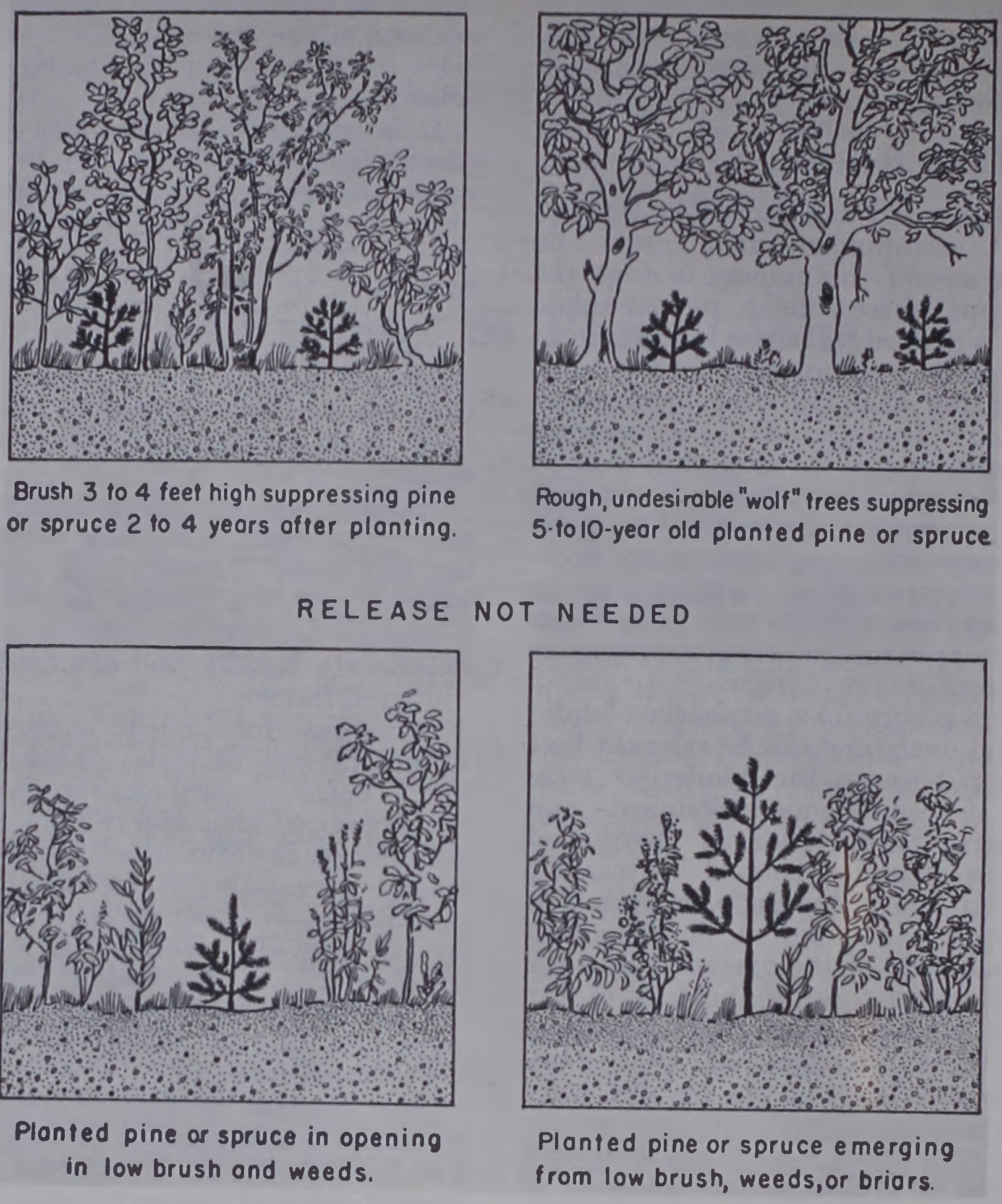

Figure 30.—Conditions under which release of planted trees is and is not needed.

importance today may change. The tables, therefore, may not include all of the pests which could seriously affect the success of species commonly planted. If serious outbreaks occur, professional advice on control measures should be obtained.

Serious damage to young plantations of all species by white grubs (*Phyllophaga* spp.) may occur in some sections of the Central States. On those sites where high infestations do occur, however, some control measures are desirable. If sample excavations made in late spring or summer indicate a population of more than one white grub per cubic foot of soil, serious damage to planted seedlings is likely. To reduce mortality on these sites, the roots of seedlings should be dipped in a 2-percent aldrin emulsion just before planting. Attachments for spraying chemicals on the roots of seedlings and surrounding soil are obtainable for some planting machines. For spraying of this kind for white grubs, a 1-percent emulsion of aldrin is recommended.

Where to Get More Help

Much additional information on tree planting is found in the references given in this bulletin (see Literature Cited, p. 57). Technical assistance in planning tree-planting projects may be obtained from the local farm (or service) forester. The names and addresses of farm foresters can be obtained from the State Division of Forestry (see list, p. 23). In addition, the County Agricultural Agent, consulting forester, and the local Soil Conservation Service leader may supply the information desired or give advice on contacting the State extension forester, State Agricultural Experiment Station, or U.S. Forest Service Experiment Stations.

Species Selection Guides and How to Use Them

Species Selection Guides have been prepared for each State in the region to aid the landowner in choosing the right species for planting (tables 9–14). Although the landowner usually has some latitude in deciding what products to grow (see tables 2 and 3, pp. 14 and 15), the species selected to grow these products *must* be adapted to the local climate and site. The importance of choosing only those species adapted to the site cannot be overemphasized.

The guides are prepared to aid in on-the-ground recognition of those features of soil, topography, and vegetation that are important in choosing species for planting. Unless the landowner is familiar with these features on the land selected for planting, he should examine the site or have it examined by a qualified technician before choosing the species and deciding what methods of site preparation and planting to use.

The guides are intended primarily for plantings for erosion control and the growing of wood products. Although a number of the species included are also suitable for Christmas trees, the list of species for this purpose is by no means complete.

In selecting species for each site, careful consideration was given to recommendations from the woodland conservationists of the Soil Conservation Service and from foresters of the State divisions of forestry and agricultural experiment stations in the region (*6*, *7*, *110*). The forestry staff of Iowa State University was especially helpful in preparing the Guide for that State (*64*).

TABLE 9.—*Species selection guide for forest planting in Illinois*

Planting site class	Soil series (*135*, *149*, *164*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
1. Severely eroded land; sheet erosion so severe that there is less than 3 inches of topsoil. May or may not be gullied:			
a. North of U.S. Route 40	All severely eroded soils	jack pine redcedar red pine	red pine redcedar jack pine
b. South of U.S. Route 40	do	shortleaf pine Virginia pine redcedar	shortleaf pine redcedar Virginia pine
NORTHERN ILLINOIS[1] UPLANDS			
2. Well-drained, medium-textured soils, with permeable subsoils. Level to steeply sloping land:			
a. North and east aspects[2]	Seaton, Fayette, Downs, Dodgeville (d.ph.), Ellison, Fox, Onarga, Alvin, Dubuque (d.ph.), Clary, Baylis, Camden, Palestine.	white pine Norway spruce red pine European larch black walnut black locust	white pine black walnut white ash Norway spruce N. red oak
b. South and west aspects	do	red pine Norway spruce Europen larch redcedar black locust	white pine Norway spruce N. red oak blace walnut white ash redcedar

See footnotes at end of table.

TABLE 9.—*Species selection guide for forest planting in Illinois*—Continued

Planting site class	Soil series (*135, 149, 164*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
NORTHERN ILLINOIS[1] UPLANDS—Continued			
3. Moderately well-drained, medium-textured soils; subsoils tight but moderately permeable. Slightly more droughty than soils in Planting Site Class 2. Rolling to steep uplands:			
a. North and east aspects[2]	Schapville (d.ph.), Morley, Blount, Beecher, Starks, Clinton, O'Fallon, Hickory.	red pine jack pine white pine European larch Norway spruce redcedar	white pine N. red oak Norway spruce white ash redcedar
b. South and west aspects	do	red pine jack pine redcedar	red pine redcedar Norway spruce
4. Moderate to poorly drained, medium-textured soils; fine-textured silty or clayey subsoils. Nearly level to steeply sloping land.	Schapville (sh.ph.), Eylar, Chatsworth, Berwick, Atlas, Fishhook, Tomalco, Colp, Stoy.	sycamore cottonwood white ash white pine redcedar	white ash green ash redcedar white pine sycamore
5. Sandy soils, or loamy sands, excessively droughty except where high water tables occur. May have sandstone bedrock 20 to 30 inches below surface. Water table deeper than 4 feet in midsummer:			
a. North and east aspects	Sumner, Hagner, Bloomfield, Unity, Plainfield, Perks.	white pine red pine jack pine redcedar	white pine red pine redcedar
b. South and west aspects	do	jack pine redcedar	redcedar
6. Well-drained, medium-textured soils that occur over calcareous sands and gravels. These are characteristically droughty soils in late summer and early fall.	Lorenzo, Rodman, Chute, Hennepin, Bold.	red pine jack pine white pine	white pine red pine jack pine
7. Shallow soils over bedrock less than 15 inches from surface. Bedrock usually limestone. (In driftless area of northwestern Illinois.)	Dodgeville, Romeo, Sogn, Rough stoney land.	redcedar jack pine	redcedar
NORTHERN ILLINOIS[1] LOWLANDS			
8. Sands and loamy sands: a. Water table 18 inches to 4 feet from surface in midsummer.[2]	Homer, Watseka, Maumee, Kilbourne, Hoopston, Cowling, Milroy.	white pine red pine jack pine Norway spruce European larch	white pine Norway spruce red pine
b. Water table less than 18 inches from surface in midsummer.	do	cottonwood sycamore silver maple	Do not plant.
9. Heavy clay bottom lands, normally dark colored. Claypans. Difficult planting sites.	Denny, Brooklyn, Ward	sycamore cottonwood redcedar	Do.
10. Poorly drained mineral or organic soils in depressions. Natural regeneration usually better than planting.	Houghton, Lena	Do not plant	Do.

See footnotes at end of table.

TABLE 9.—*Species selection guide for forest planting in Illinois*—Continued

Planting site class	Soil series (*135, 149, 164*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
SOUTHERN ILLINOIS CLAYPAN AREA (Gently sloping uplands and poorly drained upland flats)			
11. Medium to fine-textured, gently rolling eroded soils, moderately permeable.	Richview, Ava, Grantsburg, Hosmer, Sciotoville, Stolle, Bogeta.	shortleaf pine loblolly pine red pine redcedar	shortleaf pine white pine loblolly pine red pine redcedar
12. Fine-textured, imperfect to somewhat poorly drained soils; silty or clayey mottled subsoils. Nearly level to rolling lands.[2]	Weinbach, Robbs, Stoy, Colp, Bluford, Hurst.	redcedar sycamore cottonwood Virginia pine	redcedar sycamore pin oak
13. Claypans; very slowly permeable mottled subsoils; level.	Cisne, Wynoose, Ward, Cowden, Weir, Henry, Ginat.	sycamore sweetgum cottonwood redcedar	Do not plant.
SOUTHERN ILLINOIS HILLY UPLANDS			
14. Well-drained, medium-textured soils that occur on gently rolling to steep land; moderately permeable with little or no restriction to root development. Includes a few soils with fragipans that somewhat restrict root penetration:			
a. Topsoil at least 7 inches thick, generally but not always on northerly and easterly slopes, coves, and lower slopes.[2]	Alford, Stookey, Hickory, Zanesville, Wartrace.	shortleaf pine loblolly pine white pine black walnut black locust	North and east aspects: yellow-poplar N. red oak black walnut white ash white pine loblolly pine South and west aspects: white pine loblolly pine N. red oak shortleaf pine
b. Topsoil 3 to 7 inches thick, generally on upper south and west slopes and dry, exposed ridges.	----do----	shortleaf pine loblolly pine white pine redcedar	white pine loblolly pine shortleaf pine redcedar
15. Shallow soils over chert or solid bedrock.	Rough Stoney Land, Bodine, Muskingum, Wellston.	shortleaf pine redcedar loblolly pine	redcedar shortleaf pine loblolly pine

See footnotes at end of table.

TABLE 9.—*Species selection guide for forest planting in Illinois*—Continued

Planting site class	Soil series (*135, 149, 164*)	Species to plant, in order of preferen	
		On open poorly stocked land	On cutover or partly stocked la
SOUTHERN ILLINOIS BOTTOM LANDS			
16. Deep sandy to medium-textured silty soils, periodically flooded:			
a. Well drained; no standing water on surface or to depths of 18 inches for periods longer than 10 days during growing season.[2]	*Alluvial bottom lands:* Haymond, Wakeland, Sharon, Belknap, Kemper, Birds, Bonnie, Beaucoup. *Terraces:* Wheeling, Camden, Palestine, Onarga, Alvin, Sumner, Hagner, Bloomfield, Perks, Uniontown, Drury.	cottonwood sycamore sweetgum yellow-poplar black walnut white ash silver maple	sweetgum yellow-poplar black walnut white ash bur oak
b. Frequently ponded; water standing on surface or to depth of 18 inches for periods longer than 10 consecutive days during growing season.[2]	----do----------	cottonwood sycamore sweetgum silver maple baldcypress	sweetgum white ash sycamore cottonwood pin oak

[1] Northern Illinois includes entire State north of the Claypan area, roughly all land north of a line from Paris Edgar County to Alton in Jersey County.

[2] On cutover and partly stocked land, dense forest and ground cover may make this a difficult planting chan Control of vegetation will be expensive because two or more release cuttings may be needed after the initial clearing.

TABLE 10.—*Species selection guide for Indiana*

Planting site class	Soil series (*117*)	Species to plant, in order of preferenc	
		On open poorly stocked land	On cutover or partly stocked lan
1. Severely eroded land; sheet erosion so severe that there is less than 3 inches topsoil; may or may not be gullied:			
a. North of U.S. Route 40----------	All severely eroded soils----------	jack pine red pine	red pine
b. South of U.S. Route 40----------	----do----------	Virginia pine shortleaf pine loblolly pine	Virginia pine shortleaf pine
GLACIAL SOILS (including old lake beds, outwash plains, and hilly uplands)			
2. Well-drained and moderately well-drained sandy soils. The surface soils are usually slightly to medium acid. These soils are underlain by sand, gravel, or stones and are highly permeable. Level to gently sloping land.[1]	Berrien, Boyer, Casco, Coloma, Fox, Nekoosa, Oakville, Oshtemo, Ottawa, Ottokee, Perrin, Plainfield, Rodman, Seward, Spinks, Teegarden, Tyner.	red pine jack pine white pine	white pine
3. Well-drained or moderately well-drained, medium-textured soils with a root zone generally permeable. Subsoils usually clayey, but somewhat permeable. Uplands and plains:			
a. More than 7 inches of topsoil; erosion slight to moderate.[1]	Belmore, Bremen, Cana, Celina, Cincinnati, Edenton, Gibson, Grayford, Hanna, Hillsdale, Jennings, Kalamazoo, Longlois, Miami, Negley, Parke, Pike, Rossmoyne, Rush, Russell, Sisson, Sunfield, Tracy, Tuscola, Wynn, Xenia.	white pine red pine	white pine yellow-poplar black walnut N. red oak

See footnotes at end of table.

TABLE 10.—*Species selection guide for Indiana*—Continued

Planting site class	Soil series (*117*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
GLACIAL SOILS (including old lake beds, outwash plains, and hilly uplands)—Continued			
b. Topsoil 3 to 7 inches thick; erosion moderate to severe.	-----do-----	white pine jack pine red pine	white pine N. red oak red pine
4. Well-drained upland and lacustrine soils with slowly to very slowly permeable clay subsoils. Gently rolling to steep land.	Aboite, Galena, Lucas, Markland, Morley, St. Clair, Uniontown.	shortleaf pine [2] loblolly pine [3] white pine	white pine shortleaf pine [2] loblolly pine [3]
5. Imperfectly to poorly drained soils with silt pans or claypans on gently sloping to slightly undulating land. Subsoils usually saturated in spring of the year.	Avonburg, Clermont, Loy, Mullins, Vigo, Weir.	sweetgum sycamore cottonwood pin oak	sweetgum pin oak sycamore
RESIDUAL UPLAND SOILS (chiefly of sandstone, shale, and limestone origin)			
6. Well and moderately well-drained, medium-textured soils that occur on gently rolling to steep land; moderately permeable with little or no restriction to root development. Derived principally from sandstone and shale. Includes a few soils with fragipans that somewhat restrict root penetration:			
a. Topsoil at least 7 inches thick, generally but not always on northerly and easterly slopes, coves, and lower slopes.[1]	Muskingum, Tilsit, Wellston, Zanesville, Christian (derived partly from loessial material).	white pine loblolly pine [3] shortleaf pine yellow-poplar	North and east aspects: yellow-poplar N. red oak black walnut white ash white pine loblolly pine [3] South and west aspects: white pine loblolly pine [3] N. red oak shortleaf pine
b. Topsoil 3 to 7 inches thick, generally on upper south and west slopes and dry, exposed ridges.	-----do-----	white pine shortleaf pine loblolly pine [3]	white pine shortleaf pine
7. Well-drained to excessively well-drained, coarse and medium-textured soils on rolling to steep land. Underlain immediately by shale or coarse to medium-textured subsoils.	Colyer-----	shortleaf pine loblolly pine [3]	shortleaf pine loblolly pine [3]
8. Poorly to imperfectly drained soils with siltpan or claypans that restrict root penetration and water movement. Nearly level uplands usually saturated in spring.	Johnsburg-----	sweetgum sycamore shortleaf pine loblolly pine [3]	sweetgum N. red oak white ash shortleaf pine loblolly pine [3]
9. Shallow rocky limestone soils, with fine-textured subsoil; limestone bedrock 6 to 20 inches below surface. Strongly sloping to steep:			
a. Topsoil more than 7 inches-----	Fairmount, Corydon, Milton, (shallow phase) Orleans, Rugby.	white pine shortleaf pine	white pine shortleaf pine
b. Topsoil 3 to 7 inches-----	-----do-----	shortleaf pine	white pine shortleaf pine

See footnotes at end of table.

TABLE 10.—*Species selection guide for Indiana*—Continued

Planting site class	Soil series (*117*)	Species to plant, in order of preferen	
		On open poorly stocked land	On cutover or partly stocked la
RESIDUAL UPLAND SOILS (chiefly of sandstone, shale, and limestone origin)—Continued			
10. Well-drained, deep limestone soils, either rocky or shallow limestone. Limestone bedrock usually deeper than 20 inches. Gentle to strongly sloping uplands:			
a. Topsoil more than 7 inches [1]	Crider, Bewleyville, Frederick, Hagertown, Pembroke, Russellville.	white pine shortleaf pine loblolly pine black walnut [3] black locust white ash red oak	North and east aspects: black walnut N. red oak white ash white pine South and west aspects: white pine loblolly pine [3] black walnut N. red oak white ash
b. Topsoil 3 to 7 inches	do	shortleaf pine loblolly pine [3] white pine	white pine
WINDBLOWN UPLAND SOILS (parts of southwestern Indiana)			
11. Well-drained, deep soils developed in relatively thick deposits of windblown loessial materials, on gently sloping to steep topography.	Bloomfield, Hosmer, Manlove, Oaktown, Princeton, Birbeck.	shortleaf pine white pine	white pine shortleaf pine
BOTTOM-LAND SOILS (first bottoms, terraces, and depressions, derived from varied materials)			
12. Well- to moderately well-drained, medium-textured soils on first bottoms and terraces along streams and rivers.[1]	Adler, Eel, Boehne, Elkinsville, Genesee, Griffin, Huntington, Haymond, Lindside, Martinsville, Rahm, Morganfield, Philo, Pope, Pekin, Ockley, Sciotoville, Uniontown, Wheeling, Wilbur, Woodmere.	cottonwood sweetgum baldcypress [4] white pine black walnut white ash	white ash sycamore black walnut sweetgum white pine
13. Imperfectly to poorly drained soils on level to slightly undulating areas. Subsoils usually saturated with water in spring of year.[1]	*Developed from limestone:* Guthrie, Lawrence. *Developed from glacial till:* Washtenaw, Bethel, Delmar, Inwood, Blount, Nappanee, Crosby, Brookston, Kokomo, Keysport. *Developed from outwash, terrace, or lacustrine (lake-bed) soils:* Whitaker, Sleeth, Westland, Abbington, Kibbee, Colwood, Robinson, Mahalasville, Needham, Bartle, Peoga, Vincennes, Weinbach, Ginat, Chilo, Henshaw, Patton, Dubois. *Developed from loess:* Reesville. Ward, Ragsdale, Iva, Ayrshire. *Developed from loess, sandstone, and shale:* Mullins.	sweetgum sycamore cottonwood silver maple baldcypress [4]	sweetgum silver maple

See footnotes at end of table.

TABLE 10.—*Species selection guide for Indiana*—Continued

Planting site class	Soil series (*117*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
BOTTOM-LAND SOILS (first bottoms, terraces, and depressions, derived from varied materials)—Continued			
14. Poorly drained organic soils	Carlisle, Tawas, Linwood, Willette, Rifle, Peat, Adrian, Palms, Houghton, Edwards, Warners, Kerston, Wallkill.	Do not plant	Do not plant.

[1] On cutover and partly stocked land, dense forest and ground cover may make this a difficult planting chance. Control of vegetation will be expensive because two or more release cuttings may be needed after the initial clearing.
[2] Do not plant shortleaf pine north of U.S. Route 40.
[3] Do not plant loblolly pine north of U.S. Route 50.
[4] Plant baldcypress only on sites south of U.S. Route 40.

TABLE 11.—*Species selection guide for Iowa*

Planting site class	Common soil series (*158*)	Species to plant, in order of preference
EASTERN IOWA (from U.S. Route 69 east to the Mississippi River)		
. Sandy soils, or finer-textured soils over bedrock less than 15 inches from surface.	Sogn, Thurman, Dickinson, Chelsea, Lamont, steep stony land.	*North and east aspects, coves and second bottoms:* white pine, red pine, jack pine, redcedar. *South and west aspects, ridgetops:* jack pine, red pine, redcedar.
. Deep, well-drained medium-textured soils; generally permeable, but includes some that are moderately impermeable at depths greater than 18 inches.	Fayette, Dubuque, Quandahl, Tama, Carrington, Coggon, Chaseburg, Givin, Berwick, Mahaska, Otley, Taintor, mixed alluvium.	*North and east aspects, coves and second bottoms:* white pine, red pine, European larch, Norway spruce,[1] white spruce,[1] black walnut, cottonwood, green ash. *South and west aspects:* white pine, red pine, jack pine, European larch. *Alluvial bottom-land soils:* cottonwood, sycamore, silver maple, green ash, hackberry, black walnut.
Moderate to poorly drained, shallow, clay loams, silty clays, and clays; "tight" slowly permeable, subsoils.	Zwingle, Schapville, Traer, Marion, Weller, Lindley, Shelby, Gosport, Keomah, Bucknell, Pershing, Belinda, Bauer, Grundy, Haig, Sperry, Seymour, Edina, Clarinda, Lagonda, mixed alluvium.	*North and east aspects, coves and second bottoms:* green ash, redcedar, white pine, hackberry, cottonwood, silver maple, Norway spruce.[1] *South and west aspects:* redcedar, jack pine, cottonwood, green ash, hackberry. *Bottom lands:* cottonwood, green ash, sycamore, silver maple.
WESTERN IOWA (from U.S. Route 69 to western boundary of State)		
Droughty soils; well-drained sandy, or medium-textured soils with low moisture-holding capacity.	Hamburg, Ida, Arion	Redcedar.
Deep, well-drained soils; generally permeable but includes some soils that are moderately impermeable at depths greater than 18 inches.	Monona, Marshall, Castana, Napier, Steinauer, Minden, Hornick-first bottom, Sharpsburg, Winterset, Ladoga, Nodaway, mixed alluvium.	*North and east aspects, coves and second bottoms:* redcedar, European larch, white pine,[2] black walnut, cottonwood, white spruce.[2] *South and west aspects:* redcedar, jack pine, European larch. *Bottom lands:* cottonwood, silver maple, hackberry, black walnut, sycamore.

See footnotes at end of table.

WESTERN IOWA (from U.S. Route 69 to western boundary of State)—Continued

6. Moderate to poorly drained, shallow clay loams, silty clays, and clays; "tight," slowly permeable subsoils.	Clarinda, Luton-first bottoms, Shelby, Lagonda, Gara, Malvern, Wabash, and mixed alluvium.	*North and east aspects, coves and se bottoms:* redcedar, sycamore, cot wood, green ash, silver maple, h berry. *South and west aspects:* redcedar, bur sycamore, cottonwood, hackberry. *Bottom lands:* sycamore, cottonwood, s maple, green ash.

[1] Plant in northeast Iowa only, north of U.S. Route 6.
[2] Do not plant on sites with calcareous topsoils.

TABLE 12.—*Species selection guide for Kentucky*

Planting site class	Soil series (*73*)	Species to plant, in order of preferen	
		On open poorly stocked land	On cutover o partly stocked l
1. Severely eroded land; sheet erosion so severe that there is less than 3 inches of topsoil; may or may not be severly gullied:			
a. Subsoil coarse to moderately fine-textured.	All severely eroded soils	loblolly pine shortleaf pine Virginia pine	loblolly pine shortleaf pine Virginia pine
b. Subsoil fine-textured with compact clay, sometimes with limestone slabs or marl outcrops.	do	redcedar	redcedar
2. Well-drained to moderately well-drained, medium-textured, moderately deep to shallow soils on gently rolling to steep land; derived from sandstone, shale, and/or silt stones.			
a. Coarse to medium-textured subsoils, generally on north and east steep slopes.[2]	Hector (cool slopes)[1] Muskingum (cool slopes).	white pine loblolly pine shortleaf pine black walnut black locust	yellow-poplar N. red oak black walnut white ash white pine loblolly pine
b. Soils moderately deep to fragipans, or shallow to sandstone or shale, on level to sloping land. (Muskingum and Hector on sloping to steep.)	Bedford, Captina, Cincinnati, Coolville, Dickson, Freeland, Grenada, Hector (lower hot slopes),[1] Kenton, Landisburg, Lax, Leadvale, Loudon, Mercer, Mobely, Monongahela, Muskingum (lower hot slopes),[1] Nicholson, Pearman, Providence, Richland, Rossmoyne, Sango, Sciotoville, Tilsit, Whitwell, Zaleski, Zanesville.	loblolly pine shortleaf pine white pine	white pine loblolly pine shortleaf pine
3. Deep, well-drained, gentle to strongly sloping upland and terrace soils; with rapid to moderately permeable, medium to moderately fine-textured subsoils; underlain by limestones, sandstones, and/or shales:			
a. Topsoil more than 7 inches thick[2]	Allegheny, Apison, Allen, Ashburn, Ashton, Armour, Bealeyville, Baxter, Brandon, Braxton, Christian, Cookeville, Caylor, Capshaw, Crossville, Crider, Cruze, Cumberland, Decatur, Dexter, Ells, Etowah, Franks-town, Faceville, Fleming, Hagerstown, Hayter, Hermitage, Holston, Humphreys, Jefferson, Loradale, Loring, Lexington, Linker Kintonia, Malt, Manse, Memphis, Maury, Mountview, Nolichucky, Pembroke, Pace, Negley, Pickwick, Rennox, Rus-ton, Russelville, Sequatchie, Shelbyville, Waynesboro, Wheeling, Wolftever, Trappist, Wellston.	white pine loblolly pine shortleaf pine black walnut black locust	white pine loblolly pine N. red oak black walnut yellow-poplar white ash
b. Topsoil 3 to 7 inches thick		shortleaf pine loblolly pine white pine	white pine loblolly pine shortleaf pine

See footnotes at end of table.

TABLE 12.—*Species selection guide for Kentucky*—Continued

Planting site class	Soil series (*73*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
Well-drained to excessively well-drained coarse and medium-textured soils on rolling to steep land; underlain immediately by shale or coarse-textured parent material of variable origin.	Bodine, Beulah, Bruno, Colyer, Culleoka, Guin, Hartsells, Iola, Lakin, Muskingum (upper hot slope),[1] Rockcastle, Westmoreland.	shortleaf pine loblolly pine	loblolly pine shortleaf pine
Well- to moderately well-drained upland soils with thin clay subsoils, or rocky and shallow to thin-bedded limestones or calcareous shale with clay subsoils; usually eroded.	Ashwood, Eden, Edenton, Colbert, Talbott, Caneyville, Corydon, Fairmount, Otway, Tumbez, Westmoreland (very rocky phase), Ashburn (very rocky phase), Hagerstown (shallow and rocky phases), Maury (shallow phase), Pembroke (shallow and rocky phases), Salvisa (very rocky phase).	redcedar	redcedar
Well-drained upland and terrace soils with medium to slow internal drainage and clay subsoils of limestone and/or shale origin; gently to strongly sloping:			
a. Topsoil more than 7 inches thick[2]	Beasley, Bigbone, Brashear, Donerail, Enders, Hampshire, Heitt, Jessup, Licking, Lowell, Maddox, Markland, Muse, Needmore, Rarden, Salvisa silt loam Swaim, Uniontown, Upshur, Weon, Woolper.	white pine shortleaf pine loblolly pine	white pine N. red oak
b. Topsoil 3 to 7 inches thick	do	redcedar	redcedar
Moderately well- to well-drained, medium to coarse-textured bottom soils of variable origin. Fertile, highly productive land.[2]	Adler, Barbourville, Collins, Commerce, Egam, Ennis, Huntington, Hymon, Lindside, Lobelville, Morganfield, Philo, Pope, Robinsonville, Staser, Shannon, Vicksburg.	cottonwood yellow-poplar black walnut black locust sweetgum white pine loblolly pine baldcypress cherrybark oak	Do not plant unless cleared and cultivated: cottonwood yellow-poplar black walnut black locust sweetgum cherrybark oak white pine loblolly pine baldcypress
Poorly to somewhat poorly drained bottom, terrace, and upland soils.			
a. Slopes less than 2 percent.[2]	Atkins, Avonburg, Blago, Burgin, Calhoun, Calloway, Carroll, Caseyville, Clermont, Cotaco, Dekoven, Dunning, Elkins, Falaya, Fawcett, Ginat, Guthrie, Henry, Henshaw, Ina, Inglefield, Johnsburg, Lawrence, Lee, Lickdale, McGary, Melvin, Mhoon, Mullins, Newark, Olivier, Purdy, Robertsville, Roellen, Sees, Stendal, Taft, Tupelo, Tyler, Waverly, Weinbach, Zipp.	baldcypress sweetgum sycamore pin oak cottonwood	sweetgum pin oak sycamore baldcypress
b. Slopes 2 percent or more.[2]		baldcypress loblolly pine shortleaf pine sycamore sweetgum pin oak	sweetgum pin oak sycamore baldcypress loblolly pine
Very sandy, alluvial soils along streams and rivers.[2]	Clack, Crevasse, sandy alluvial land.	cottonwood sycamore sweetgum baldcypress	sweetgum sycamore cottonwood baldcypress

[1] "Hot slopes" are generally on south and west aspects, between Azimuth readings of 125° to 340°; "cool slopes" generally north and east aspects between Azimuth readings of 340° and 125°.

[2] On cutover and partly stocked land, dense forest and ground cover may make this a difficult planting chance. Control of vegetation will be expensive because two or more release cuttings may be needed after the initial clearing.

TABLE 13a.—*Species selection guide for Missouri*

Planting site class	Common soil series [1] (*70, 71, 95, 150*)	Species to plant, in order of prefere
NORTHERN AND WESTERN MISSOURI (north of Missouri River and west of the Ozarks)		
1. Well-drained sandy soil, or medium-textured soils with low water-holding capacity; some soils shallow to sandstone bedrock at 20 to 30 inches. (Includes "river hills" and bluffs.)	Sarpy sandy loam (60–64), Cass sandy loam (52), Boone (26–27), Knox-Menfro (18), Shallow Huntington (92–93), Marshall-Pettis (14), Nodaway-Sharon (66).	*Uplands:* redcedar, white pine.[2] *Bottom lands:* cottonwood, silver m hackberry, sycamore.
2. Deep, moderately well to somewhat poorly drained medium-textured soils; includes some soils with 40 inches or more of silty surface soils and silty clay to clay subsoils.	Grundy (11), Shelby (16), Summit (11), Tama (14), Union (20), Winfield (20), Lindley (21).	*North and east aspects:* black walnut, ash, black locust, cottonwood, ye poplar,[2] white pine.[2] *South and west aspects:* jack pine, redc *Bottom lands:* cottonwood, sycar green ash, black walnut.
3. Poorly drained fine-textured soils with "tight" claypan subsoils.	Edina (28), Marion (10), Mexico-Parsons (24), Osage clay-Wabash clay (58), Putnam-Oswego (15), Seymour (29), Weldon (25).	*Uplands:* redcedar, sycamore, co wood, green ash, hackberry, s maple. *Bottom lands:* sycamore, cottonw green ash, hackberry.

[1] The list of soil series in each planting site class is not complete; the number in parentheses following a soil s refers to the basic soil series symbol occurring on soil surveys currently being made in Missouri by the Soil Conserv Service.

[2] Plant white pine only in part of Missouri north of the Missouri River and east of U.S. Highway No. 63, on n and east aspects of soils specified. Plant yellow-poplar on recommended soils in only the following localities: the "I heel," and the eastern Ozark border region.

TABLE 13b.—*Species selection guide for Missouri*

Planting site class	Common soil series [1] (*70, 71, 95, 150*)	Species to plant, in order of prefere	
		On open poorly stocked land	On cutover o partly stocked
OZARK REGION			
4. Severely eroded land; less than 3 inches of topsoil; gullied.	All severely eroded soils	eastern redcedar shortleaf pine loblolly pine [3]	eastern redceda shortleaf pine loblolly pine [3]
5. Well-drained, medium-textured soils; permeable subsoils for 40 inches or more. On areas bordering prairie some of these soils may have rock, sand, or gravel at 24- to 36-inch depths, and somewhat droughty. Level to steeply sloping land, uplands and bottom lands:			
a. North and east aspects	Baxter (2), Craig (6), Loring-Memphis (19), Hagerstown (1).	shortleaf pine loblolly pine [3] eastern redcedar black locust black walnut	black walnut eastern redceda green ash yellow-poplar [2]
b. South and west aspects	do	shortleaf pine loblolly pine [3] eastern redcedar	shortleaf pine loblolly pine [3] eastern redceda
c. Bottom land	Huntington-Robinsonville (66)	loblolly pine [3] shortleaf pine black walnut	black walnut loblolly pine [3]
6. Well-drained, stony or cherty-silty surface soils; permeable subsoil with rock, sand or gravel. Droughty soils on rolling to steep slopes.	Baxter cherty (3) or stony (4), Bodine cherty (5) or stony (4), Clarksville cherty (5) or stony (4), Elden (7), Gosport (17–31), Snead stony (13), Sogn stony (13).	shortleaf pine loblolly pine [3] eastern redcedar	shortleaf pine eastern redceda loblolly pine [3]

See footnotes at end of table.

TABLE 13b.—*Species selection guide for Missouri*—Continued

Planting site class	Common soil series [1] (*70, 71, 95, 150*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
OZARK REGION—Continued			
Moderate- to poorly drained, medium-textured surface soils, and 40 inches or more of fine-textured subsoils (silty clay to clay). Some of the soils near prairie land may have very heavy (claypan) subsoils. Level to steeply sloping land:			
a. Uplands	Grenada (20), Guthrie (10), Lebanon (9), Union (20), Nixa-Dixon (8).	loblolly pine [3] eastern redcedar shortleaf pine	eastern redcedar shortleaf pine loblolly pine [3] green ash
b. Lowlands	Robertsville-Calhoun (10), Waverly (76).	loblolly pine [3] sycamore cottonwood green ash	Do not plant unless cleared: sycamore cottonwood green ash
Sandy soils, excessively drained and droughty. Upland soils have sandstone bedrock at 20 to 30 inches. Uplands and bottom lands (stream gravel):			
a. Uplands	Hanceville (26), Tilsit (23), Collinsville (27).	shortleaf pine loblolly pine [3]	shortleaf pine loblolly pine [3]
b. Lowlands	Stream gravel (96); bottom lands: shallow to sandy or gravelly (91–94).	cottonwood sycamore loblolly pine [3]	Do not plant unless cleared: cottonwood sycamore
SOUTHEASTERN LOWLANDS (the "Bootheel," and adjoining counties)			
Poorly drained, silt to clay surface soils and clay subsoils; includes the "gumbo" bottom lands; level to gently rolling land.	Alligator (79), Olivier (25), Robertsville (10), Sharkey (78), Waverly (76), imperfectly to poorly drained bottom-land soils with silty clay subsurfaces (67–54).	sycamore sweetgum cottonwood silver maple baldcypress	Do not plant.
Sandy to medium-textured, silty soils, deep, highly permeable:			
a. Well-drained; no standing water on surface or to depths of 18 inches for periods longer than 10 consecutive days during growing season.[4]	Beulah (64), Clack (60), Sarpy (64), deep, well-drained bottom-land soils (66).	cottonwood sycamore sweetgum yellow-poplar black walnut white ash silver maple baldcypress cherrybark oak	sweetgum yellow-poplar black walnut white ash cherrybark oak
b. Frequently ponded; water standing on surface or to depth of 18 inches for periods longer than 10 consecutive days during growing season.[4]	-----do-----	cottonwood sycamore sweetgum silver maple baldcypress	sweetgum white ash sycamore cottonwood

The list of soil series in each planting site class is not complete; the number in parentheses following a soil series to the basic soil series symbol occurring on soil surveys currently being made in Missouri by the Soil Conservation ce.

Plant white pine only in part of Missouri north of the Missouri River and east of U.S. Highway No. 63, on north and aspects of soils specified. Plant yellow-poplar on recommended soils in only the following localities: the "Bootheel," he eastern Ozark border region.

Loblolly pine recommended only in counties adjoining Arkansas.

On cutover and partly stocked land, dense forest and ground cover may make this a difficult planting chance. Control of vegetation will be expensive because two or more release cuttings may be needed after the initial clearing.

TABLE 14.—*Species selection guide for Ohio*

Planting site class	Soil series (*104, 107, 108*)	Species to plant, in order of prefere	
		On open poorly stocked land	On cutover partly stocked
RESIDUAL SOILS OF SOUTHERN AND SOUTHEASTERN OHIO			
1. Severely eroded land; sheet erosion so severe that there is less than 3 inches of topsoil. May or may not be gullied.	All severely eroded soils	Virginia pine shortleaf pine [1] loblolly pine [2] white pine	loblolly pine [2] Virginia pine shortleaf pine [1] white pine
2. Well-drained, medium-textured soils that occur on gently rolling to steep land; moderately permeable with little or no restriction to root development:			
a. Topsoil at least 7 inches thick, generally but not always on northerly and easterly slopes, coves, and lower slopes.[3]	*Derived chiefly from sandstone and shale:* Wellston, Zanesville, Tilsit, Alford, Frankstown, Tuscarawas, Muskingum, Meigs, Stony Muskingum, Stony Meigs, Gilpin. *Derived partly from limestone or other calcareous material:* Brooke, Belmont, Westmoreland.	white pine loblolly pine [2] shortleaf pine [1] red pine [4] yellow-poplar black walnut black locust European larch	yellow-poplar N. red oak black walnut white ash white pine loblolly pine [2]
b. Topsoil 3 to 7 inches thick, generally on upper south and west slopes and dry, exposed ridges.	do	white pine shortleaf pine [1] loblolly pine [2] red pine [4]	white pine shortleaf pine [1] loblolly pine [2] red pine [4]
3. Well-drained uplands soils with moderate to slowly permeable clay subsoils. Rolling to steep land.	Rarden, Latham, Eifort, Trappist, Upshur, Coolville, Keene, Byington, Fawcett, Guernsey.	shortleaf pine [1] loblolly pine [2] white pine red pine [4]	white pine shortleaf pine [1] loblolly pine [2] red pine [4]
4. Shallow well-drained to excessively well-drained, medium-textured soils on rolling to steep land. Underlain immediately by black shales.	Colyer	shortleaf pine [1] loblolly pine [2] Virginia pine white pine red pine [4]	shortleaf pine [1] loblolly pine [2] white pine
5. Soils with clay subsoils of poor physical conditions, derived from calcareous shales. Moderately steep and usually severely eroded:			
a. Slight to moderate erosion; topsoil 3 to 7 inches thick.	Shallow Otway, Shallow Jacksonville, Shallow Bentonville.	redcedar white pine Austrian pine Virginia pine	redcedar white pine Austrian pine Virginia pine
b. Severely eroded; topsoil less than 3 inches thick; gullied.	do	redcedar Virginia pine	redcedar Virginia pine
6. Shallow rocky limestone soils, with fine-textured subsoil. Limestone bedrock 6 to 20 inches below surface. Strongly sloping to steep:			
a. Topsoil more than 7 inches thick	Fairmount, Heitt, Otway, Corydon, Shallow Cedarville, Shallow or Stony Bratton.	redcedar white pine shortleaf pine [1]	white pine redcedar shortleaf pine [1]
b. Topsoil 3 to 7 inches thick	do	redcedar shortleaf pine [1] Virginia pine	shortleaf pine [1] Virginia pine redcedar

See footnotes at end of table.

TABLE 14.—*Species selection guide for Ohio*—Continued

Planting site class	Soil series (*104, 107, 108*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
RESIDUAL SOILS OF SOUTHERN AND SOUTHEASTERN OHIO—Continued			
7. Well- and moderately drained deep limestone soils, derived from limestone. Limestone bedrock usually deeper than 20 inches. Gentle to strongly sloping uplands:			
a. Topsoil more than 7 inches thick [3]	Hagerstown, Maddox, Cedarville, Bratton, Bedford, Deep Jacksonville, Deep Bentonville.	white pine shortleaf pine [1] loblolly pine [2] yellow-poplar black walnut black locust white ash Norway spruce	white pine yellow-poplar black walnut N. red oak white ash Norway spruce
b. Topsoil 3 to 7 inches thick	do	shortleaf pine [1] Austrian pine loblolly pine [2] white pine	white pine loblolly pine [2] shortleaf pine [1] Austrian pine
GLACIAL SANDSTONE AND SHALE SOILS OF NORTHEASTERN OHIO			
5. Severely eroded land; sheet erosion so severe that there is less than 3 inches of topsoil. May or may not be gullied.	All severely eroded soils	Virginia pine jack pine red pine [4]	Virginia pine jack pine red pine [4]
1. Shallow, droughty soils developed from thin glacial till over sandstone outcrops, or from acid sands and gravels.	Loudonville, Millwood, Massillon	Virginia pine red pine [4] jack pine white pine	white pine red pine [4]
1. Well- and moderately well-drained, deep medium- to fine-textured soils with a medium to slowly permeable root zone:			
a. More than 7 inches of topsoil; erosion negligible. [3]	Ellsworth, Wooster, Hanover, Fallsburg, Rittman, Canfield, Alexandria, Wayne.	white pine Norway spruce European larch	white pine black walnut Norway spruce
b. Topsoil 3 to 7 inches thick; erosion moderate to severe.	do	yellow-poplar sweetgum white ash black walnut white pine jack pine red pine [4]	white ash N. red oak sweetgum sycamore white pine N. red oak red pine [4]
Imperfect to very poorly drained, medium- to fine-textured deep soils on level or gently rolling till plains. [3]	Wadsworth, Ravenna, Mahoning, Frenchtown, Marengo, Venango, Trumbull.	sycamore sweetgum pin oak cottonwood silver maple baldcypress	sweetgum pin oak silver maple
GLACIAL LIMESTONE SOILS OF WESTERN OHIO			
Severely eroded land; sheet erosion so severe that there is less than 3 inches of topsoil. May or may not be seriously gullied:			
a. Subsoils coarse to medium textured.	All severely eroded soils	Virginia pine shortleaf pine [1] loblolly pine [2]	Virginia pine shortleaf pine [1] loblolly pine [2] jack pine
b. Subsoils fine textured, with calcareous, compact clay.	do	redcedar Virginia pine	redcedar Virginia pine

See footnotes at end of table.

TABLE 14.—*Species selection guide for Ohio*—Continued

Planting site class	Soil series (*104, 107, 108*)	Species to plant, in order of prefere	
		On open poorly stocked land	On cutover partly stocked
GLACIAL LIMESTONE SOILS OF WESTERN OHIO—Continued			
13. Shallow to moderately deep medium-textured soils underlain by gravel, calcareous glacial till, shale, or limestone.	Shallow Milton, Milton, Mill Creek, Ockley, Wea, Fox, Negley, Casco, Edenton, Romeo, Hennepin, Wynn, Rodman, Warsaw, Parke, Pike.	white pine red pine Austrian pine shortleaf pine [1] loblolly pine [2] redcedar	white pine Austrian pine shortleaf pine [1] loblolly pine [2] redcedar
14. Well- and moderately well-drained, deep medium- to fine-textured soils with medium to slowly permeable root zones. a. More than 7 inches of topsoil; erosion negligible.[3]	Celina, Caesar, Ionia, Sardinia, Thackery, Tippecanoe, Corwin, Xenia, Dana, Cardington, Birkbeck, Grayford, Miami, Williamsburg, Kendallville, Russell, Wawaka, Sidell, Saybrook, Morley, Uniontown, Varna, Loudon, Rossmoyne, Jessup, Cincinnati, Jennings.	white pine Austrian pine shortleaf pine [1] loblolly pine [2] sweetgum Norway spruce	white pine yellow-poplar black walnut white ash sweetgum N. red oak
b. Topsoil 3 to 7 inches thick; erosion moderate to severe.		Austrian pine shortleaf pine [1] loblolly pine [2] white pine	Norway spruce white pine N. red oak loblolly pine [2] shortleaf pine [1]
15. Imperfect to very poorly drained, deep, medium- to fine-textured soils with medium to slow permeability; level to gently undulating till plains or in depressions.[3]	Crosby, Massie, Sleeth, Crane, Weinbach, Odell, Fincastle, Bennington, Raub, Bonbas, Blount, Henshaw, Randolph, Blanchester, Elliot, Pitchin, Brookston, Westland, Montgomery, Abington, Kokomo, Millsdale, McGary, Cope, Pewamo, Chippewa, Ragsdale, Clermont, Bethel, Delmar, Condit, Wickliffe, Avonburg.	sweetgum sycamore baldcypress cottonwood pin oak European larch	sweetgum white ash silver maple
LAKE PLAINS SOILS OF NORTHERN AND NORTHWESTERN OHIO			
16. Moderately well-drained, fine- to very fine-textured soils with a slow to very slowly permeable root zone. Sloping to moderately steep land: a. Topsoil more than 7 inches thick	Lucas, St. Clair, Broughton	white pine red pine [4] Austrian pine Norway spruce	white pine Norway spruce Austrian pine red pine [4]
b. Topsoil less than 7 inches thick	do	red pine [4] white pine Norway spruce	white pine Norway spruce Austrian pine red pine [4]
17. Well-drained to poorly drained sandy soils. The surface soils are usually slightly to medium acid. These soils are highly permeable. Level to gently sloping land: a. Water table deeper than 4 feet in summer.	Ottokee, Oakville, Plainfield, Seward, Painesville, Haney, Tuscola.	jack pine red pine [4] white pine	white pine red pine [4]
b. Water table 18 inches to 4 feet in summer.	Rimer, Kibbie, Tedrow, Digby	white pine jack pine red pine [4]	white pine red pine [4]
c. Water table less than 18 inches deep in summer.	Wauseon, Reynolds, Colwood, Milgrove, Granby, Maumee.	cottonwood sycamore sweetgum silver maple	Do not plant

See footnotes at end of table.

TABLE 14.—*Species selection guide for Ohio*—Continued

LAKE PLAINS SOILS OF NORTHERN AND NORTHWESTERN OHIO—Continued

Planting site class	Soil series (*104, 107, 108*)	Species to plant, in order of preference	
		On open poorly stocked land	On cutover or partly stocked land
Poorly and imperfectly drained medium- to fine-textured soils on level areas. Subsoils usually saturated in spring.[3]	Paulding, Nappanee, Toledo, Fulton, Hoytville, Latty, Caneadea, Canadice, Lorain, Fries, Olmstead, Wilmer, Haskins, Mermill, Roselms, Wickliffe.	sycamore sweetgum silver maple cottonwood	sweetgum silver maple sycamore cottonwood
Poorly drained organic soils in depressional areas. (Natural regeneration usually better than planting).	Muck, peat	Do not plant	Do not plant.
BOTTOM-LAND (ALLUVIAL) SOILS THROUGHOUT OHIO			
Well-drained medium-textured soils on first and second bottoms along streams and rivers.[3]	Eel, Lobdell, Philo, Linside, Senecaville, Medway, Genessee, Chagrin, Pope, Huntinton, Moshannon, Ross, Chili, Mentor, Holston, Monongahela, Wheeling, Colerain, Vincent, Glenford, (Vause).	cottonwood sweetgum baldcypress white pine black walnut white ash Norway spruce European larch	white ash sycamore baldcypress black walnut sweetgum white pine
Poorly to very poorly drained soils on level to slightly undulating areas. Subsoils usually saturated with water in spring of year.[3]	Shoals, Orrville, Stendal, Newark, Defiance, Sloan, Papakating, Dunning, Elkins, Wabash, Tyler, Algiers, Wallkill, Melvin, Atkins.	sweetgum sycamore baldcypress cottonwood silver maple	sweetgum silver maple baldcypress

[1] Do not plant shortleaf pine north of U.S. Route 40.

[2] Do not plant loblolly pine north of U.S. Route 50, and use stock from Maryland, Delaware, or Virginia seed sources y.

[3] On cutover and partly stocked land, dense forest and ground cover may make this a difficult planting chance. ntrol of vegetation will be expensive because two or more release cuttings may be needed after the initial clearing.

[4] European pine shoot moth is a very serious pest of red pine, particularly on sites located north of U.S. Route 40.

The information given in the Species Selection ides is classified under three major headings: nting Site Class, Soil Series, and Species to nt. Under the first, Planting Site Class, in the -hand column, are listed the distinctive site tures that can be recognized by an appraisal of face characteristics and soil properties. Each nting site class is assigned an identifying num- . In some States the U.S. Soil Conservation vice has classified soils for forest planting into ups. Each group consists of soil series that are newhat similar in such soil properties as tex- e, rooting depth, drainage, parent material, and ductivity. In States where this information available, the planting site classes are based narily on these soil groups.

However, in order that other important factors efly depth of topsoil, slope position, aspect, and sion) that vary within soil groups and soil series be considered, a further breakdown of plant- site classes into subclasses is necessary. Subses are designated as "a," "b," "c," and so h. For example, Planting Site Class No. 2 for Ohio is subdivided into 2a (more than 7 inches topsoil), and 2b (topsoil 3 to 7 inches thick).

Most planting site classes include two or more soil groups and many soil series. Even though there may be differences in characteristics among the soil groups and series in one planting site class, the same species in the same order of priority are suitable for planting on any of them. White pine, for example, may grow faster on some soils than on other soils in the same class, but it is nevertheless the best species for planting on all soils in the class.

The soil series associated with each planting site class are listed in the middle column of the Species Selection Guides. For readers familiar with this system of soil classification, or if up-to-date-soil survey maps are available, this list of soil series will aid in identifying planting site classes.

Species to plant appear in the double column on the right. Species are listed for each site in order of preference; except for Iowa and northern Missouri, separate lists are given for open, poorly stocked land and for cutover or partly stocked land.

Seriously eroded and gullied land presents special problems and is suitable for only a few species in each State (fig. 31). Such land is, therefore, not correlated with any specific soil group or series.

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Figure 31.—Few species are adapted to severely eroded land. Compare growth and survival of 7-year-old trees in foregroun where all topsoil has been eroded, with background where 1 to 3 inches of topsoil remain, for white (*A*), pitch (*B*), loblolly (C and Virginia pines (*D*).

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Appendix

SUGGESTED PROCEDURES FOR MAKING PLANTING PLANS

The degree of detail required in making plans for planting depends to a large extent on the size of the area to be planted, the number of tracts to be planted, number of years required to complete the planting, the complexity of site conditions, and the existing knowledge of these site conditions. On small plantings no formal planting plans are necessary; on large operations, however, it is desirable to make site evaluations and to prepare "blueprints" for the planting. The following step-by-step procedures may be helpful in preparing these plans.

Land Ownership Status

Examine deeds to verify land ownership; look especially for easements granting rights to construct highways, powerlines, pipelines, or reservoirs, and for reservations in the title that provide rights for strip mining. Exclude these areas from the proposed planting site.

Appraisal of Planting Needs

1. *Cover classes.*—Survey each tract to determine the acreage of (1) land that does not need planting, (2) open, poorly stocked land, (3) cutover or partly stocked land, and (4) strip-mined land. On a large scale map (4 inches to the mile is suggested) mark out the boundaries of land in each of these classes.

2. *Site evaluation.*—Make a systematic survey of the land to be planted in sufficient detail to outline on the map those areas with major differences in soil texture and structure, depth of topsoil, effective rooting depth, drainage, topography, parent material, and past use.

3. *Planting site classes and subclasses.*—Consult the Species Selection Guide (p. 41) for the State in which the planting site is located. Select the planting site classes and subclasses that most closely coincide with the site-evaluation data.

Access Roads and Fire Lanes

It is well to plan and lay out a road and fire-lane system in advance of planting. This will facilitate planting and future management of the plantation, especially if the land is to be furrowed, cultivated, or cleared. In general one truck trail 15 to 20 feet wide through each 40-acre block will suffice. Make use of old, established routes of travel as much as possible, unless they are so located that they constitute erosion hazards. If fire risks are high, fire lanes surrounding each 40 acres of plantation are desirable (p. 39).

Site Preparation

If site preparation is necessary, designate
tion, area, and kind on the map (see p. 16 to

The Planting Job

In planning a large planting project it wi
helpful to prepare a separate "Planting pres
tion" for each area differing from others in met
of site preparation, species to be used, spacing
planting arrangement. The prescription sh
include the methods of site preparation plan
number of trees by species needed, spacing,
whether planting will be pure or mixed
mixed planting is planned the method of mix
should be prescribed. The seed source and st
quality specifications should be included, as
as cost estimates and lists of equipment and
terials needed.

DIRECTIONS FOR TREATMENT SEED AND METHODS OF SO ING FOR THE DIRECT SEEDI OF PINE [5]

Seed Treatment

Quick, prompt germination improves the
for success by reducing the period of exposur
predators and adverse weather. Seeds of
southern pines except longleaf are somev
dormant and require cold, moist stratificatio
speed germination. Stratification is in alterna
layers of wet peat moss or other suitable mat
at about 36° F.

The stratification period varies by species
individual lots. The only sure way to deterr
it is to test the germination of samples strat
for different lengths of time. When such t
are impractical, blanket recommendations ar
stratify loblolly for 60 days, slash for 30, short
for 45 to 60, sand for 15 to 30, Virginia for 30,
white pine for 30.

There is an easy way to stratify small lots
home refrigerator. Seeds are soaked in water
several hours and then placed in a polyethy
bag which is tied shut and refrigerated at ab
38° F. for the length of time recommended ab
for each species. Enough water should be ad
periodically to rewet surfaces of seeds when t
dry out.

Repellent coatings are added after stratificat
The same repellents and stickers have perfor
well with all southern pine species. Arasan
and anthraquinone are used almost exclusi
for protection against birds—at concentration

[5] Excerpts from "How to Direct-Seed the Sout
Pines," by William F. Mann, Jr. (*84*).

0 pounds of Arasan–75 and 15 pounds of anthra-
inone per hundred pounds of seed. Arasan–75
ives a more durable coating, but is highly irri-
ting to the eyes, throat, and mucous mem-
anes of those who must handle the seed. Hence
nthraquinone is preferred for hand-sowing opera-
ons. (See "Safety Precautions," p. 23.)

Stauffer's Endrin 50W, applied at the rate of
pounds per 100 pounds of seed, is standard for
otection against insects and rodents. It should
thoroughly blended with the bird repellent
fore application to insure that all seeds are
ated uniformly.

A light aluminum overcoating hastens drying
the repellent coating and lubricates seeds so
at they flow freely through hoppers. About
upful per hundred pounds of seed is ample.

Either Dow Latex 512–R or Flintkote's asphalt
ulsion C–13–HPC is a suitable sticker. Latex
diluted with clean, soft water in the ratio of
) and asphalt 1:3. Latex is easier and cleaner
mix and apply, but requires careful handling
l storage.

With a wire basket, and equipment made from
steel drums, two men can treat 1,000 pounds
seed daily. One drum has the top removed:
used to apply the sticker. The fine-meshed,
vy-wire basket is about 20 inches deep. It
ds the seed when it is dipped into the sticker.
other drum is used to apply the chemical.
as a close-fitting but removable cover and is
inted on an axle so that it tumbles end-over-
when the crank is turned. A single set of
les is welded inside the drum to help mix the
and repellents.

he sticker is mixed with water in the dipping
n. It should be stirred at regular intervals
ng the treating operation. Unused sticker
ld be discarded and a fresh batch prepared
ne start of each day's work.

ne treating procedure is as follows: Put 35
0 pounds of dewinged seed (amount varies
pecies) into the basket and lower it into the
er. Stir the seed with a paddle. In about 2
ites, lift the basket and allow the surplus
er to drain off for about 30 seconds. Draining
nore than 30 seconds is hazardous because the
er quickly sets, resulting in a poor bond of
lents to the seed. Next, pour seed into the
ng drum, add a weighed amount of repellent,
tir it into the seed with a paddle. Then close
over tightly and rotate the drum for about
nutes. To coat with aluminum, add powder
ne drum and tumble for another minute.
ly, remove the coated seed and spread it out
y in a layer 2 or 3 inches thick on paper or
as.

all lots can be repellent-coated with the aid
lard can, a small basket made of window
n, and heavy-weight paper bags. One-pound
es are best. Seed is placed in the basket and
d into the sticker in the lard can. It is
d for about 2 minutes, lifted out, allowed to drain for 30 seconds, and poured into a paper bag. A weighed quantity of blended repellents is then put into the bag, which is closed tightly and shaken vigorously for about 60 seconds. If it is desired to overcoat with aluminum, one or two teaspoons of the powder can be added and the bag shaken again for about 30 seconds. Finally, the seed is spread out to dry.

The seed can be sown as soon as it is dry enough to handle—the less delay the better. If inclement weather delays sowing, the seed can be held safely for 2 weeks in a well-ventilated, unheated building or a refrigerated room.

Methods of Sowing

Sowing can be done by hand or with seeding guns, hand-operated "cyclone" seeders, airplanes, helicopters, or tractor-drawn machines.

Distribution by hand is efficient on small areas of disked strips or plowed furrows. One man can cover 15 to 20 acres per day, and seed is conserved because it is cast only on the prepared parts.

The "cyclone" hand-operated seeder is useful for broadcast sowing on tracts up to 200 acres in size. One man can sow about 20 acres a day. Its greatest utility is on areas that are irregular in shape or where scattered patches of established pines are to be bypassed.

Fixed-wing airplanes and small helicopters have been used extensively in the past 5 years. Both give excellent distribution and precise sowing rates. They are best adapted for large operations. A light plane can cover up to 1,500 acres per day and a helicopter 3,000 acres.

Tractor-drawn machines have also come into wide use in recent years. There are now at least 10 models, and more may be expected. All have one feature in common: they prepare a seedbed and sow in rows at a single pass. They can be broadly grouped as furrow seeders and disk seeders.

Furrow seeders have either a middle-buster plow pulled behind a tractor or a V-plow mounted at the front of a tractor. Most of the pulled models have an arrangement to bury the seed or press it into firm contact with the soil. They are best suited for sandy soils where seeds broadcast on the surface fail to germinate adequately. Front-end models also work best on sandy soils, and they can operate in moderately heavy brush. With either type, about 20 acres can be covered daily.

Disk seeders were developed to sow two rows simultaneously with the same tractor power required for single-row furrow seeders. They can sow about 30 acres per day. They have two separate offset disk units, each about 1½ feet wide and 4 to 5 feet apart. Seeds are dropped directly on the disked soil and pressed down by a packing wheel. Sowing rates must be higher than with furrow seeders, because considerable seed is lost from silting.

Though tractor-drawn implements have some advantages over those for broadcast sowing, most have sharp limitations. Therefore, all types should be carefully investigated to deter if a particular machine is adapted to soil and conditions on the area to be regenerated.

INSECT PESTS OF FOREST PLANTATIONS [1]

Tree species and pest [2]	Symptoms	Control measure	
		Insecticide	Reference
			Author [3]
Ash, green and white:			
The ash borer *Podosesia syringae fraxini* (Lug.)	Bore trunk at ground level	DDT spray on trunk.	
Oystershell scale *Lepidosaphes ulmi* (L.)	Weakens tree, may kill	Dormant oil spray	English (*43*)
Fall webworm *Hyphantria cunea* (Drury)	Webbing of branches, foilage	Lead arsenate	do
Catalpa:			
Catalpa sphinx *Ceratomia catalpae* (Bdv.)	Defoliation	Lead arsenate or DDT spray.	do
Cottonwood:			
Poplar borer *Saperda calcarata* (Say)	Frass at base of tree	DDT application on trunk	do
Poplar and willow borer *Sternochetus lapathi* (L.)	Bore in branches and trunk	DDT application	do
Cottonwood leaf beetle *Chrysomela scripta* (F.)	Leaves skeletonized	Lead arsenate or DDT spray	do
Hackberry:			
Hackberry nipple gall *Pachypsylla celtidis-mamma* (Flet.)	Conspicuous growths on leaves	Lindane spray	English (*43*)
Larch, European:			
Spruce budworm *Chroistoneura fumiferana* (Clem.)	Defoliation	DDT	Craighead (*34*)
Larch sawfly *Pristiphora erichsonii* (Htg.)	do	do	do
Locust, black:			
Locust borer *Megacyllene robiniae* (Forst.)	Bores into sapwood, heartwood.	DDT spray	English (*43*)
Maple, silver:			
Maple callus borer *Sylvora acerni* (Clem.)	Frass around wounds	None recommended.	Craighead (*34*)
Cottony maple scale *Pulvinaria innumerabilis* (Rathv.)	Cottony mass on branches, twigs.	Dormant spray winter, malathion summer.	English (*43*)
Oak, red, bur:			
Kermes pubescens (Bogue)	Distort—kill, shoots, leaves	Dormant oil spray.	do
Gall insects numerous species (cynipids).	Abnormal swelling of twigs	Rarely serious enough to justify spraying.	do
Osage-orange:			
Fruit tree leaf roller *Archips argyrospila* (Wlk.)	Web leaves together	DDT spray	Craighead (*34*)
European fruit lecanium *Lecanium corni* (Bouché)	Scale on twigs, branches	Dormant spray	do
Pine:			
Sawflies *Neodiprion* spp.	Defoliation	DDT	English (*43*) McDowell (*82*)
Bark beetles *Ips* spp., *Dendroctonus* spp.	Engraving in cambium area	BHC	Craighead (*34*)
Weevils *Hylobius* spp., *Pissodes* spp	Gnawing of bark and cambium.	do	do

See footnotes at end of table.

INSECT PESTS OF FOREST PLANTATIONS [1]—Continued

Tree species and pest [2]	Symptoms	Control measure		
		Insecticide	Reference	
			Author [3]	Page
Pine, loblolly, shortleaf:				
Rhyacionia frustrana (Comst.) *Rhyacionia rigidana* (Fern)	Bud and twig mortality	DDT	English (*43*)	57
Pine, red:				
European pine shoot moth *Rhyacionia buoliana* (Schiff)	Bud mortality, brooming	do	do McDowell (*82*)	57 59 60
Pine, Scotch:				
Zimmerman pine moth *Dioryctria zimmermani* (Grote)	Terminal, tree killing	do	English (*43*)	58
Pine, white:				
White pine weevil *Pissodes strobi* (Peck)	New growth on leader turns over and wilts, needles and bark turn brown, resin blobs on leader.	DDT	Craighead (*34*)	281 287
Redcedar, eastern:				
Bagworm *Thyridopteryx ephemeraeformis* (Haw.)	Defoliation	Malathion	English (*43*)	37
Aphid *Cinara sabine*	Honeydew on branches	DDT	McDowell (*82*)	46
Spruce, Norway, white:				
Spruce budworm *Choristoneura fumiferana* (Clem)	Defoliation	do	Craighead (*34*)	480 482
Eastern spruce gall aphid *Chermes abietis* L.	Pineapplelike galls on twigs	Lindane	English (*43*)	64
Sweetgum:				
Forest tent caterpillar *Malacosoma disstria* Hbn.	Defoliation	Lead arsenate spray.	Craighead (*34*)	418
Sycamore:				
Sycamore lace bug *Corythucha ciliata* (Say)	Leaves become pale and dry	Malathion spray	English (*43*)	65
Bagworm *Thyridopteryx ephemeraeformis* (Haw.)	Feeds on leaves	Lead arsenate or malathion spray.	do	66
Walnut, black:				
Walnut caterpillar *Datana integerrima* G. & R.	Defoliation	Lead arsenate or DDT spray.	English (*43*)	67
Black walnut curculio *Conotrachelus retentus* (Say)	Crescent-shaped scar on husk or young nut.	Lead arsenate	do	69
Yellow-poplar:				
Tuliptree scale *Toumeyella liriodendri* (Gmel.)	Scales on branches, twigs	Dormant spray	Craighead (*34*)	147

[1] The author is indebted to the Division of Forest Insects, Central States Forest Experiment Station, for material presented in this table.

[2] White grubs are injurious to nearly all tree species planted; for control measures see p. 40.

[3] See Literature Cited, p. 57.

DISEASES OF FOREST PLANTATIONS [1]

Tree species and disease	Symptoms	Control
Ash, white and green:		
Anthracnose (*Marssonia fraxini*).	Large, irregular brown areas, numerous along leaf margin progressing inward to midveins.	No control practical in forest trees; on ornamentals use organic mercury (*22*) or Bordeaux spray.[2]
Catalpa:		
Verticillium wilt (*Verticillium alboatrum*).	One to several branches wilt. Discolored streaks in sapwood of affected branches are first purple and later bluish brown.	Remove and burn infected trees (*14*).

See footnotes at end of table.

DISEASES OF FOREST PLANTATIONS [1]—Continued

Tree species and disease	Symptoms	Control
Cottonwood:		
Dothichiza canker (*Dothichiza populea*).	Dark-colored cankers on stems and branches which over a period of years enlarge and girdle the tree.	Plant disease-free stock avoid w ing (*12, 114*).
Hackberry:		
Witches'-broom (Gall mite—powdery mildew complex).	Swelling, widening buds with enlarged, distorted bud scales; shoots are dwarfed and clustered, becoming broomlike in appearance.	No control (*14, 22*).
Larch, European:		
Larch canker (*Dasyscypha willkommii*).	Depressed branch and stem cankers with small white to orange, cuplike fruiting bodies around the edge.	This disease is believed to have successfully eradicated from U.S. Trees suspected of bei fected with larch canker shou reported to the nearest Sta Federal tree disease specialis *14, 114*).
Locust, black:		
Verticillium wilt (*Verticillium alboatrum*).	Brownish streaks in wood, wilting branches.	No control (*14, 22*).
Maple, silver:		
Nectria canker (*Nectria cinnabarina*).	Target-shaped lesions with sloughing discolored, sunken bark; lesions produce perennial cankers.	Tree removal, sanitation proce site improvement (*14, 22*).
Verticillium wilt (*Verticillium alboatrum*).	Greenish streaks in wood. Wilting branches generally followed by tree death.	No control (*14, 22*).
Tar spot (*Rhytisma acerinum*).	Yellow-green spots that become shiny black, erupted and thickened.	No control (*14, 22, 62*).
Oaks:		
Oak wilt (*Ceratocystis fagacearum*).	*Red oaks:* leaves curl around midrib, bronze discoloration of leaves, severe defoliation, death of tree. *White oaks:* similar to red oaks except that symptoms are often confined to one or several branches. White oaks may live for several years and some may recover.	Fell diseased trees and spray top stump with mixture of DDT BHC, and spray stump with 2 T (*19, 57*).
Twig blight (*Sphaeropsis quercina*).	Dieback of twigs and branches accompanied by black streaking in the sapwood. Black fruiting bodies the size of a pinhead in the dead bark. Infected trees are sometimes killed.	Prune out and burn all diseased v (*114*).
Anthracnose (*Gnomonia veneta*).	Brown dead areas in the leaves, often triangular in shape, defoliation.	No control practical (*12, 14, 114*)
Leaf blister (*Taphrina coerulescens*)	Circular, raised, wrinkled, yellowish areas on the leaves.	No contol practical (*14, 114*).
Pines:		
Root rot (*Fomes annosus*).	In plantations, causes rapid decline and death of trees, usually in groups 3 years or more after first thinning; presence of thin white mycelial fans under bark of roots and root crown, with soft-stringy rot in wood; endemic in natural stands, causing root and butt rot.	Careful planting to avoid root cr ing and injury; increased spa to defer need for thinning; trea stumps with creosote during t ning operations may help; a establishing new plantings in a where root rot is prevalent; practical control in natural st (*41, 53, 58, 94, 161*).
Root and butt rot (*Polyporus schweinitzii*).	Crowns become thin with short chlorotic needles, often clustered at ends of twigs; cones form prematurely; dark-brown annual conks arise from roots or as brackets from trunk near base, and browning and death follow.	Avoid the establishment of pine p tations on sites with poor drai or high pH (*53, 180*).
Shoestring root rot (*Armillaria mellea*).	Decline in vigor of part or all of crown, followed by death, often involving groups of trees; may be sudden collapse in small trees; copious resin flow at base of trunk in pines; mycelial fans and rhizomorphs present under bark at base and roots; honey-colored mushrooms sometimes present.	Usually associated with weake trees; no practical control (*14,*

See footnotes at end of table.

DISEASES OF FOREST PLANTATIONS [1]—Continued

Tree species and disease	Symptoms	Control
nes—Continued Dwarfmistletoe (*Arceuthobium* spp.).	Witches'-broom in the crown with fusiform swellings on infected branches; swollen trunk infections finally becoming cankerous, predisposing trees to windbreak; short fragile, yellow to green mistletoe shoots usually present in infected areas.	Remove infected trees in stand during logging operations; no infected trees should be left for seed source (*14*).
Needle cast (Spp. of *Lophodermium*, *Hypoderma*, *Hypodermella*, and *Bifusella*.)	Needles turn red or brown and are shed prematurely; tiny, black fruit bodies appear on infected needles, usually after they fall to the ground.	Control not practical in most cases; *Lophodermium pinastri* can be controlled with 8–8–100 Bordeaux spray [2] (*14*, *15*).
nes, 2 to 3 needled: Gall and blister rusts (*Cronartium* spp.).	Slightly spindle-shaped fusiform or globose swelling on twigs, branches, or stems, giving rise to white bladderlike fruit bodies which rupture in spring to expose orange-yellow spore masses; perennial cankers sometimes formed on trunk infections with certain *Cronartium* spp.	No control practical in forest stands; galls of *Cronartium harknessii* on ponderosa pine can be pruned off; certain silvicultural practices will reduce damage caused by *C. fusiforme* in loblolly plantations (*12*, *14*, *160*).
Pine needle rusts (*Coleosporium* spp.).	Small, white blisterlike pustules on needles containing orange-yellow spore masses; repeated infection and defoliation on young trees cause reduction in growth; not serious on older trees.	No control usually warranted (*14*).
ne, Austrian: (*See* Pines and Pines, 2 to 3 needled.)		
ne, jack: Needle blight (*Elytroderma deformans*.)	Red discoloration of foliage followed by browning and death; causes conspicuous witches'-brooms on twigs of ponderosa pine but not on jack pine; browned needles have small, narrow, dull-black fruit bodies scattered over surface; young stands are severely damaged.	No control practical except for salvage cuttings in severely damaged stands (*28*).
e, loblolly: Littleleaf disease (*Phytophthora cinnamoni* in conjunction with adverse soil conditions, including poor aeration, low fertility, and moisture stress.)	Early stages resemble symptoms of nitrogen deficiency; in advanced stages the crown is sparse and foliage appears in tufts at twig tips; needles are markedly shortened and yellow to yellow-green; sprouts develop on lower trunk, and trees produce large crops of small cones; disease rare on trees under 20 years.	Losses in forest stands can be reduced by following certain cutting practices designed to eliminate diseased trees; on park trees applications of commercial fertilizer prevent symptom development and improve conditions of trees in early stages of littleleaf (*182*).
usiform rust. (*See* Pines, 2 to 3 needled.)		
e, ponderosa: Needle blight. (*See* Pine, jack.)		
e, red: Tympanis canker (*Tympanis* spp.).	Produces annual sunken cankers on main stems at branch whorls; cankers inconspicuous until dead bark sloughs off; attacks red pine in plantings out of optimum range for species. Progressive dying from the top downward, accompanied by resin flow at the butt and a white mottling of inner bark.	Avoid establishment of red pine plantations south of optimum range for species; damage on white pine is inconsequential, and no control necessary (*12*, *14*). Avoid plantings on tight, poorly drained soil (*60*, *180*).
esinosis (Incompletely understood, usually associated with tight, poorly drained or alkaline soils and fungus infections, especially *Polyporus schweinitzii*.)		
e, Scotch: (*See* Pines and Pines, 2 to 3 needled.)		
e, shortleaf: ittleleaf disease. (*See* Pine, loblolly.)		
tch canker (*Fusarium lateritium* f. *pini*).	Copious pitch flow from cankers on stems and branches; underlying wood is characteristically pitch-soaked; white mycelial growth sometimes evident in cankers under bark.	Remove infected trees in thinning operations or other improvement cuttings (13).

ee footnotes at end of table.

DISEASES OF FOREST PLANTATIONS [1]—Continued

Tree species and disease	Symptoms	Control
Pine, Virginia: Pitch canker (*See* Pine, shortleaf).		
Pine, white: White pine blister rust (*Cronartium ribicola*).	The most conspicuous symptoms are the spindle-shaped swellings on branches and stems bearing numerous white blisters filled with orange powdery spore masses. The swellings enlarge annually, become cankerous and produce successive crops of spores which infect ribes bushes, the alternate host; cankers eventually girdle and kill infected stems.	Destroy ribes bushes in white stands and in a protective z 500 to 1,000 feet around the s Width of protective zone with climate, elevation, lat and species of pine and hosts (*93*).
Resinosis (*See* Pine, red).		
Chlorotic dwarf (Unknown).	Progressive shortening of needles and internodes, resulting in dwarfed trees which eventually die; in advanced stages only the current year's needles are present which become chlorotic and occasionally exhibit tip burn; disease is commonly found in plantations up to 15 years old.	No control known (*144*).
Eastern white pine blight needle blight (A disease of physiogenic origin. Recent evidence suggests it is caused by ozone, a naturally occurring oxidant which sometimes reaches toxic concentrations in the atmosphere during storm fronts.)	Browning and death of the outer portions of the current year's needles. May cause reduced increment; needles sometimes shortened and drop prematurely; repeated attacks may cause death; occurs both in natural stands and in plantations.	No control generally applicable. tilization and other soil imp ment measures have shown pr and are practical only where numbers of trees are inv (*37*, *145*).
Redcedar, eastern: Cedar-apple rust (*Gymnosporangium juniperi-virginianae*).	Globose, pitted swellings or galls on twigs and foliage producing conspicuous orange telial horns during rainy periods.	Avoid planting within 1 mile of a pear, hawthorn, or mountain trees (*12*, *14*, *114*).
Cedar blight (*Phomopsis junipovora*).	Twig dieback accompanied by small brown cankers or lesions on the smaller branches.	Remove and burn all dead br tips (*12*, *14*, *114*).
Fomes root rot (*See* Pines).		
Spruce, Norway: Cytospora canker (*Cytospora kunzei*)	Browning of needles, dying lower branches, resin flow.	Prune out and destroy all dise material, plant on suitable maintain vigor (*12*, *14*, *114*).
Fomes root rot (*See* Pines).		
Sphaeropsis tip blight (*Sphaeropsis ellisii*).	Brown needles and twig dieback at the ends of branches. Minute black fruiting bodies at base of affected needles and in dead bark.	Cut and burn diseased parts of spraying with organic mercur Bordeaux may be justified Christmas tree plantations [2] *22*).
Sweetgum: Sweetgum blight (Incompletely understood, but probably caused primarily by moisture shortages influenced by low rainfall, tight soils, or lowering of water table)	General decline of tree resulting in stag heading and in some cases death.	No control known (*146*).
Sycamore: Anthracnose (*Gnomonia veneta*).	Leaves and twig tips brown and die upon emergence from buds (resembles frost injury); later symptoms show brown spots along main veins that coalesce to kill leaves; twigs killed by small cankers.	No control; on ornamentals Bordeaux or organic mer sprays [2] (*14*, *22*).
Walnut, black: Anthracnose (*Gnomonia leptostyla*).	Irregular dark brown or blackish spots on leaflets, branch tips are killed; plant defoliates.	No control; on ornamentals Bordeaux sprays [2] (*144*, *167*).
Walnut blight (*Xanthomonas juglandis*).	Black, necrotic spots occur on nuts, leaves, and spring shoots.	Do.

See footnotes at end of table.

DISEASES OF FOREST PLANTATIONS [1]—Continued

Tree species and disease	Symptoms	Control
ow-poplar: ectria canker *Nectria magnoliae*).	Elliptical cankers beneath cracking bark.	No control (*14*).

[1] The author is indebted to the Division of Forest Diseases, Central States Forest Experiment Station, for material ented in this table.

[2] Bordeaux mixture is used at the rate of 8–8–100, two or three applications, applied every 14 to 21 days, starting the leaves emerge in the spring. Bordeaux mixture is prepared by dissolving 8 pounds of copper sulfate in 100 gal- of water. Eight pounds of hydrated lime are mixed with a small amount of water and the suspension added to the er sulfate solution in the spray tank and agitated.

[3] Organic mercury recommended is 10 percent phenylmercury-acetate or 7.5 percent phenylmercury-triethanolam- ium-lactate, used at the rate of 1 pint per 100 gallons of water, applied three to five times at 7- to 10-day intervals, ing when the leaves emerge in the spring.

COMMON AND SCIENTIFIC NAMES OF TREES MENTIONED

r, European	*Alnus glutinosa* (L.) Gaertn.
r, speckled (European)	*A. incana* (L.) Moench
green	*Fraxinus pennsylvanica* Marsh.
white	*F. americana* L.
cypress	*Taxodium distichum* (L.) Rich.
lder	*Acer negundo* L.
apple	*Malus* Mill. spp.
lpa, northern	*Catalpa speciosa* Warder
onwood	*Populus deltoides* Bartr.
red (slippery elm)	*Ulmus rubra* Muhl.
berry	*Celtis occidentalis* L.
n, European	*Larix decidua* Mill.
el (mountain laurel)	*Kalmia latifolia* L.
st, black	*Robinia pseudoacacia* L.
e, red	*Acer rubrum* L.
e, silver (soft maple)	*A. saccharinum* L.
black	*Quercus velutina* Lam.
bur	*Q. macrocarpa* Michx.
cherrybark	*Q. falcata* var. *pagodaefolia* Ell.
chestnut	*Q. prinus* L.
northern red	*Q. rubra* L.
pin	*Q. palustris* Muenchh.
white	*Q. alba* L.
-orange	*Maclura pomifera* (Raf.) Schneid.
mmon, common	*Diospyros virginiana* L.
Austrian	*Pinus nigra* Arnold
jack	*P. banksiana* Lamb.
loblolly	*P. taeda* L.
longleaf	*P. palustris* Mill.
pitch	*P. rigida* Mill.
ponderosa	*P. ponderosa* Laws.
red	*P. resinosa* Ait.
Scotch	*P. sylvestris* L.
shortleaf	*P. echinata* Mill.
Virginia	*P. virginiana* Mill.
white (eastern white)	*P. strobus* L.
dar, eastern	*Juniperus virginiana* L.
odendron	*Rhododendron* L. spp.
ras	*Sassafras albidum* (Nutt.) Nees
ood	*Oxydendrum arboreum* (L.) DC.
e, Norway	*Picea excelsa* Link
e, white	*P. glauca* (Moench) Voss
gum	*Liquidambar styraciflua* L.
nore, American	*Platanus occidentalis* L.
ut, black	*Juglans nigra* L.
w	*Salix* L. spp.
v-poplar (tulip tree)	*Liriodendron tulipifera* L.

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